The Dissertation Committee for Junghye Son Certifies that this is the approved version of the following dissertation:

KEY PROCESS ATTRIBUTES AND SUCCESS FACTORS FOR COLLABORATIVE ACADEMIA-INDUSTRY RESEARCH IN CONSTRUCTION INDUSTRY PROJECT MANAGEMENT

Committee:

William J. O'Brien, Supervisor

Stephen R. Thomas, Co-Supervisor

Daniel W. Halpin

John D. Borcherding

David W. Fowler

William R. Kelly

KEY PROCESS ATTRIBUTES AND SUCCESS FACTORS FOR COLLABORATIVE ACADEMIA-INDUSTRY RESEARCH IN CONSTRUCTION INDUSTRY PROJECT MANAGEMENT

by

Junghye Son, B.S.; M.S.

Dissertation

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degree of

Doctor in Philosophy

The University of Texas at Austin

December 2013

Dedication

To my husband, Seongjae Lee,

and to my parents

with love and appreciation.

Acknowledgements

I would like to express my sincere appreciation to my research supervisor, Dr. Stephen R. Thomas for his invaluable guidance, support, encouragement, and patience throughout my study. His immeasurable passion and devotion to the Construction Industry Institute (CII) have always inspired me. Without his profound knowledge and insights into CII research and his endless support, this study would not have been possible.

I am also grateful for the guidance and patience of my supervisor, Dr. William J. O'Brien. He has always encouraged me to think one step further whenever I have encountered challenges in the course of this research. He has provided crucial input that has taught me academic rigor and diligence. I would like to thank the other members of my committee, Dr. Daniel W. Halpin, Dr. John D. Borcherding, Dr. David W. Fowler, and Dr. William R. Kelly for their valuable comments and guidance. I especially want to thank Dr. Daniel W. Halpin for his participation from Purdue University.

I also extend sincere gratitude to the CII Research Committee (RC) and the RC Advisory Team. I am indebted to them for their constructive comments and helpful input throughout this study. I have always been amazed at their passion and tireless effort to improve the construction industry. I have learned as much from their enthusiasm as from industry knowledge and insight. I have always and truly enjoyed working with them.

I would like to thank CII colleagues and my fellow students in the Construction Engineering and Project Management Program at the University of Texas at Austin for giving me an opportunity to learn about CII and to enjoy living in Austin. My special thanks are extended to Kristi L. Delaney, Jacqueline K. Thomas, and my Korean friends for their warm consideration, support and encouragement throughout my study.

I would also like to express my earnest appreciation to the professors and industry practitioners who willingly participated in the interviews for this study. They did not hesitate to make time and effort to share their experience and their insight into CII research. Their valuable input has been essential to my study.

Finally, no words can describe my deepest appreciation to my husband, Seongjae Lee. Without his unconditional love, support, sacrifice, and encouragement, I would not have accomplished this study. He has always been one of the greatest supporters and mentors of my life. I would also like to express my sincere thanks to my parents, my lovely younger sister and my younger brother for their lifelong love, support, and patience.

Junghye Son

December 2013

Key Process Attributes and Success Factors for Collaborative Academia-Industry Research in Construction Industry Project Management

Junghye Son, Ph.D.

The University of Texas at Austin, 2013

Supervisor: William J. O'Brien

Co-Supervisor: Stephen R. Thomas

Research collaboration between academia and industry is a form of knowledge creation in construction industry project management. This research collaboration is motivated by the intent to provide solutions to issues and problems that industry faces through research expertise and a scientific approach. Notwithstanding the potential benefits acknowledged by researchers, collaborative academia-industry research has not been sufficiently explored and there only exist a few studies addressing research success and success factors. Several main reasons for this include; 1) the success of collaborative academia-industry research has not been well defined, 2) there exist limited empirical studies, and 3) the research process of collaborative academia-industry research has not been systematically investigated.

The primary purpose of this study is to improve the process of the collaborative academia-industry research for construction industry project management by identifying key process attributes and success factors. First, this study suggests a definition of the

success and success criteria of collaborative academia-industry research based on literature review. Then this study evaluated more than 150 research efforts of the Construction Industry Institute (CII), a non-profit research organization sponsoring academia-industry collaborative research for more than 30 years, against the established success criteria to identify successful and less than successful research efforts. Multiple methods were adopted for the evaluation including web-based surveys, research product dissemination data, journal citation counts, and expert group assessment. By analysis and triangulation of the data collected from those multiple sources, this study identified 11 research efforts for further analyses.

In-depth cases studies on the 11 research efforts were conducted focusing on the research process through interviews with a total of 39 academics and industry practitioners who participated in those research efforts. Information from interviews and other relevant data were analyzed for each case as well as across the 11 cases to identify key process attributes and factors contributing to research success. Consolidated findings from the cross-case analyses generated 9 key process attributes and associated success factors with significant potential to improve the research process of collaborative academia-industry research.

Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction

1.1 Research Motivation and Needs

The collaborative research between academics and industry practitioners has been suggested by researchers as a promising solution to close the gap between research and practice in applied science and management research (Amabile et al., 2001; Bartunek, 2007; Brown, 2004; Hodgkinson & Rousseau, 2009; Hughes et al. 2011; Van de Ven & Johnson, 2006). The researchers in construction management also pointed out that the construction industry needs more academia-industry research collaboration (Azhar, 2007; Green et al., 2009; Moncaster et al., 2010; Sexton & Lu, 2009).

One of potential benefits of collaborative research is the capability of producing practical knowledge through the synergy effect between academics and practitioners (Amabile et al., 2001). Collaborative research can also provide research participants with an opportunity to learn from people with different perspectives (Van de Ven & Johnson, 2006). Barnes et al. (2002) pointed out that research collaborations between universities and companies provide opportunities to enhance knowledge and to advance technologies. In addition, research collaborations between academic researchers and industry practitioners enable researchers to conduct research projects that are more relevant to current business practices and context (Amabile et al., 2001). Moreover, when practitioners who have participated in collaborative research return to their organizations, they could be a focal point in disseminating and implementing the research results within their organizations. From an academic perspective, researchers involved in collaboration tend to produce more publications, and their publications have more acceptance rates than other researchers due to the enhanced competence (Katz & Martin, 1997).

These benefits can be confirmed in the CII Post Research Team Survey as well. This survey is conducted by CII after every research team reports out for the purposes of research management and improvement. One of the survey questions is *"Participation on the research team was valuable to me personally and I expect to use the findings within my company"* which asks the research team participants to assess benefits perceived through research team experience. From a total of 178 respondents of 32 research teams that reported from 2008 through 2012, 156 responded "Strongly Agree" or "Agree" to this question, which means that about 88% of the survey respondents found that CII research experience was valuable. From the academic side, the number of citations of CII research products in academic journal articles has been steadily increasing since 1988 from 2 citations in 1988 to 43 citations in 2012 accumulating a total of 508 citations. The data show that an average of more than 20 journal articles have directly cited the CII research products every year since 1988, not to mention that this citation counts do not include the citations of the journal articles based on the CII research. Thus, it seems apparent that both industry and the academia have enjoyed the benefits of CII type, collaborative academia-industry research.

Nevertheless, challenges exist in conducting effective collaborative academia-industry research. It has been widely claimed that there is a rigor-relevance gap between academics and practitioners. The practitioners tend to seek more practical solutions readily applicable to real world problems in a relatively short period of time. In contrast, academic researchers by nature seek scientific theories behind those real world problems (Azar et al. 2010; Sexton & Lu, 2009; Tushman et al. 2007). This conflict brings the participants in collaborative research a challenge in figuring out how to satisfy the interests and needs of both industry and academia (Green et al., 2010).

These challenges are mainly due to the fact that research success has not been clearly defined for such research collaboration. Furthermore, there has been a lack of studies on the standards or criteria by which researchers assess research success (Barnes et al., 2006; Kulatunga et al., 2007). Bammer (2008) suggested that future research should further investigate the criteria and processes to evaluate collaborative research for adequate assessment of research performance and quality. Mohrman et al. (2001) also pointed out that there is a need for more empirical studies on collaborative academia-industry research cases. Moreover, the process of collaborative academia-industry research also needs more attention of researchers for research improvement (Suomala & Jokioinen, 2003), and there needs to be guidance to actual research process in managing such collaborative research (Barnes et al., 2006). Thus, there is a need to define success and success criteria and conduct empirical studies on actual collaborative academia-industry research processes for research improvement in achieving the success.

1.2 RESEARCH OPPORTUNITY

1.2.1 History and organization of CII

The Construction Industry Institute (CII), based at The University of Texas at Austin, is one of the major research organizations dedicated to construction industry project management research. Founded as a recommendation from Construction Industry Cost Effectiveness (CICE) projects sponsored by The Business Roundtable, CII was formally established on October 28, 1983. 28 companies became CII charter members at the end of 1983 (CII, 1993), and the membership has increased counting 136 members as of August 2013 (CII, 2013).

CII stated its mission as delivering advantages to its member companies through creation, dissemination, and implementation of knowledge and practices. To achieve its

mission, CII has formed a number of standing committees during 30 year of its history. The Implementation Committee was established in December 1984 followed by the CII Academic Council several months later. It took several more years to establish other standing committees. The Benchmarking & Metrics Committee was established in Jan 1993, and the Knowledge Management Committee was established in April 1999 producing the CII Knowledge Structure. CII started providing its products online in 2001, providing the access to the CII resources to the world at anytime.

The first three CII Communities of Practices (COPs) started in March 2007 for the purpose of sharing knowledge and expertise among practitioners on a specific topic, such as safety, sustainability, and globalization. These COPs have grown to 11 communities in 2013, reaching out to various topics including next-generation leaders and federal facilities delivery. In May 2013, the Benchmarking & Metrics Committee changed its name to the Performance Assessment Committee, expanding its spectrum to broader industry sectors. (CII, 1993; CII, 2013).

The Board of Advisors, which consists of the representatives from each member company, receives reports from the standing committees, provides general research topic ideas to the committees and prioritizes research identified by CII's Research Committee each year. The Executive Committee, comprised of the executive management of the member companies, provides the leadership for CII. Currently, there are 14 standing committees involving the representatives from member companies including the Executive Committee within CII. From these 14 committees, 7 committees are dedicated to the four core knowledge processes of CII. The four core processes are knowledge creation, knowledge dissemination, knowledge assessment, and knowledge management. Figure 1-1 illustrates these four core processes and associated standing committees.

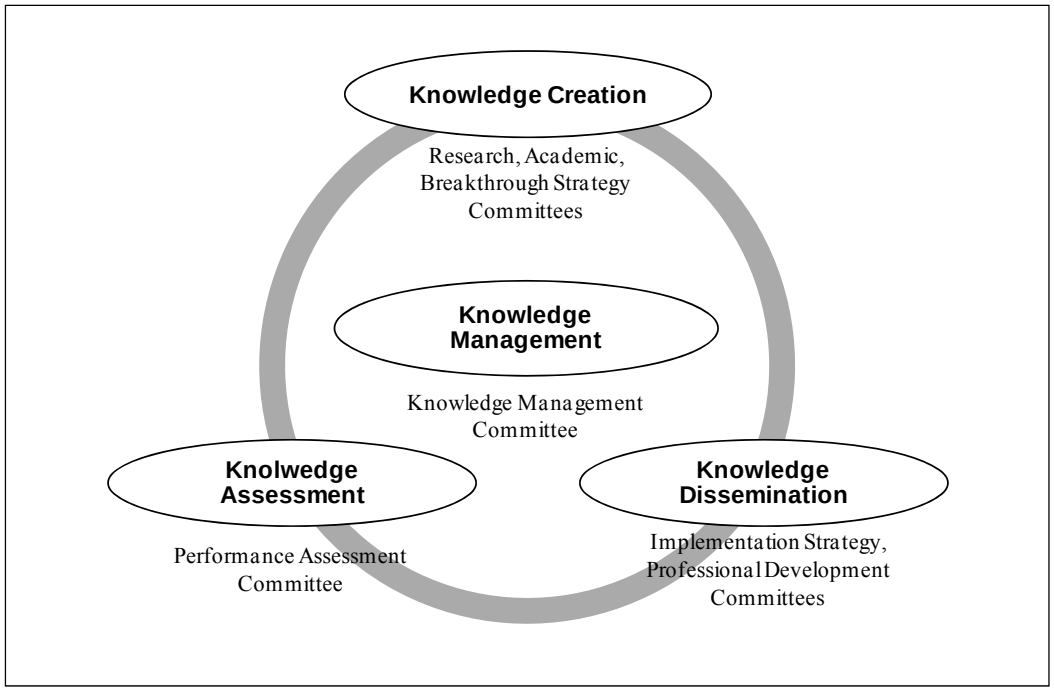


Figure 1-1: CII Core Processes

1.2.2 Uniqueness of CII research

The unique characteristic of CII research lies in the integrated and collaborative research effort between academia and industry. CII members encompass owners, contractors, and supplier companies, and these member companies actively participate in CII research efforts. They contribute to the CII knowledge creation process from two levels. First, member companies propose and decide research topics that CII will pursue each year. Second, they also participate in research as team members.

From its first operations in 1984, CII has been clear that it is a *"member-driven"* research organization and is *"responsive to the needs of its membership"* (CII, 1993; CII, 2008). From its start, it determined that the research topics would be approved by its Board of Advisors, the representatives of the member companies (CII, 1993). This topic identification and prioritization by industry has not changed for 30 years.

CII research teams consist of experienced academic researchers and industry members from various CII member companies, forming a unique joint effort between owner, contractor, and supplier companies. This framework is designed to produce quality research outcomes readily implementable by industry and to maximize the synergetic effect of academics and practitioners (CII, 2010). Since 1983 when seven research teams, called task forces, were initiated, CII has funded more than 180 research teams and produced more than 670 publications as outcomes of its research efforts. Approximately 300 academic researchers from more than 50 universities have participated as Principal Investigators on those 180 research teams, and ten to twenty industry practitioners have participated on each of those 180 teams, providing industry knowledge and expertise.

1.2.3 Opportunity for this study

CII has created a unique research model for collaboration between academia and industry to improve the construction industry through practice-based research efforts (Halpin, 2007). Halpin (2007) noted that CII has grown into a leading research organization that provides to practical solutions to the industry problems and issues based on a team which is a mix of *"academic research protocol"* and *"industry expertise"*. As Halpin (2007) indicated, CII has created a unique model, and it has also pursued and maintained the model for over 30 years with continuous improvement. An average of 6 research teams has started every year since 1983, and more recently that number has increased to nine. Every research team produces at least two research products and most more.

CII's long history and unique model provide a promising opportunity for studying collaborative academia-industry research. The opportunity appears in three aspects;

sample pool, data availability and accessibility, and data quality. First, more than 180 research efforts conducted over a 30-year period forms a rich pool for sample selection. Second, data related for these research efforts are available and accessible. CII has maintained every product of its research efforts and most of those resources are accessible online. In addition, when looked at the cross section as of August 2013, there were 18 research teams ongoing, and 35 academic researchers and approximately 350 industry practitioners were participating on those 18 research teams. Moreover, over 400 industry practitioners are currently involved in the CII standing committees and communities of practices. These academics and industry practitioners possess some level of knowledge and exposure to CII research. Third, in terms of data quality, various types of data can be acquired for CII research efforts. CII maintains not only the research products but also various data related to its research efforts. Such data include interim reports submitted by research teams, research participant surveys for research teams after reporting out, and research product downloads and sales records. These various types of data sources offer a favorable condition for data triangulation.

In summary, CII provides a great environment to collect rich information and data in terms of in-depth understanding of academia-industry research collaboration. Henceforth, it is a tremendous learning opportunity to closely look at this pioneer and role model of academia-industry research collaboration in construction industry project management.

1.3 RESEARCH PURPOSE AND OBJECTIVES

The primary purpose of this study is to improve the collaborative academia-industry research process in construction industry project management by identifying key

attributes and success factors of collaborative research processes. To achieve this purpose, four objectives were developed as presented below.

1) To define the success of collaborative academia-industry research from both the industry and academic perspectives
2) To identify and investigate collaborative academia-industry research efforts that have been acknowledged as successful and less than successful by both industry and academia
3) To identify key research process attributes and success factors leading to the research success
4) To develop recommendations for more effective and high value research

1.4 RESEARCH QUESTIONS

For each of the four objective presented in the previous section, a corresponding research question was formulated as presented below.

1) What is the success of collaborative academia-industry research in construction industry project management and what are the success criteria?
2) What are the success indicators of collaborative academia-industry research?
3) What are the key process attributes and success factors of collaborative academia-industry research?

The first research question was formulated to accomplish the first research objective, which is to define the success of collaborative academia-industry research from both the industry and academic perspectives. The first and second phases of this study answered this first research question. The second research question was developed to identify collaborative academia-industry research studies that have been acknowledged as successful and less than successful by both industry and academia, fulfilling the second

research objective. The third research question was formulated in the attempt to achieve the third objective, which is to identify the research process attributes leading to the research success and key success factors enhancing these attributes. Figure 1-2 depicts how the research needs, objectives, and questions are connected to each other.

1.5 RESEARCH SCOPE

The scope of this study is limited to collaborative academia-industry research. Research conducted solely by academics or company research and development (R&D) efforts are excluded. Secondly, data for this study are exclusively limited to CII research efforts, research studies conducted by other research organizations are not included. Next, this study focuses on the CII research process and the products developed through this process. Practice implementation and knowledge management issues within a company are not addressed.

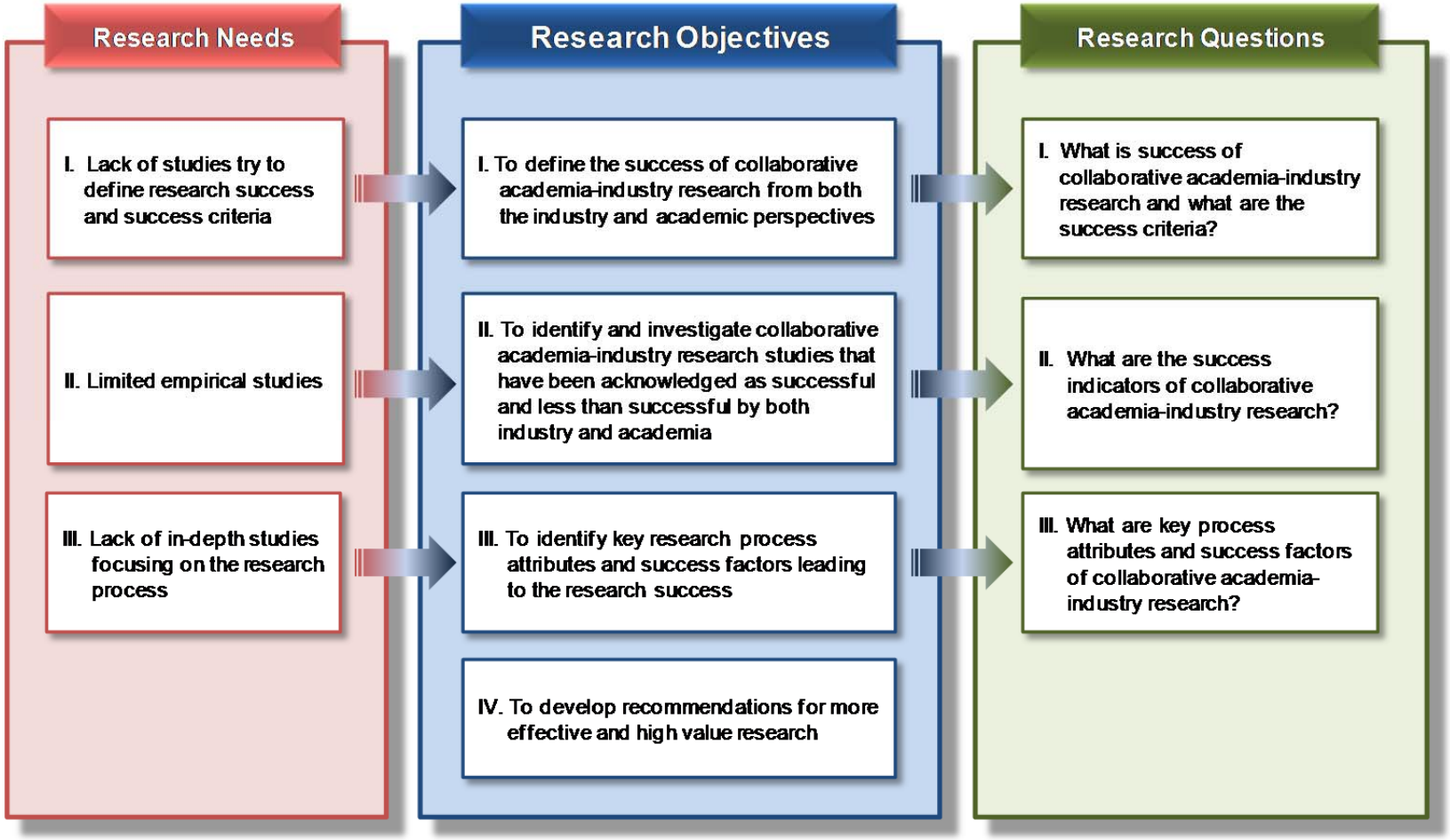


Figure 1-2: Research Needs, Objectives, and Questions

1.6 ADVISORY TEAM

An advisory team consisting of voluntary members from the CII Research Committee was established to guide this study as a concurrent effort of the committee's research quality initiative. Since its establishment, the Advisory Team has provided guidance and feedback to this study. Included among them are advice on overall research methodology and survey development, support for data collection, and interpretation of pilot survey data. One of major contributions of the Advisory Team was the incorporation of industry perspective, which increased the validity and reliability of the findings of this study. The list of a total of 13 team members is provided in Table 1-1.

1.7 ORGANIZATION OF DISSERTATION

This dissertation consists of 9 chapters. The first chapter is an introductory chapter which explains the research motivation, the research purpose and objectives, the research questions, and the research scope and limitations. This chapter also introduced the Advisory Team which was a group of industry and academic members from the CII Research Committee that provided input to this study. The next chapter is the review of literature followed by the third chapter presenting the research framework and research propositions. Chapter 4 illustrates the research methodology with summary descriptions of each step of the methodology. Chapter 5 describes the identification and selection process of cases for the in-depth focused case studies. The next chapter illustrates the details of the data collection process for the cases studies, and chapters 7 and 8 discuss the analysis and findings of the case studies. In the last chapter, the research findings and conclusions are summarized, and limitations of this study and recommendations for future research are provided as well.

Name	Position	Company
Randall J. Abdallah	Senior Vice President	Walbridge
John D. Borcherding	Adjunct Professor	The University of Texas at Austin
Barry L. Christen	Director, Engineering & International Technical Resource Centers	URS Corporation
Earl M. Clark	Engineering Manager	DuPont
James B. Gibson	Vice President, Projects Execution	Alstom Power Inc.
Daniel W. Halpin	Professor Emeritus	Purdue University
Don A. Leinweber	Vice President, Corporate Services	Wood Group Mustang
Thomas Napier	Research Architect	U.S. Army Corps of Engineers
Cynthia J. Richartz	Manager, Technical Center of Excellence	Abbott
Edward M. Ruane	Executive Director	Fluor Corporation
Stanley C. Tripp	Manager, Global Projects	LyondellBasell
Kenneth D. Walsh	Professor	San Diego State University
David C. Wolfson	Manager, Engineering Services	Air Products and Chemicals, Inc.

Table 1-1: List of the Advisory Team

Chapter 2: Background Literature Review

The primary purpose of the background literature review is to achieve the first objective by answering the first research question. The first research question is to define success and success criteria of collaborative academia-industry research. This chapter will answer this research question from the background literature review.

2.1 TERMINOLOGY

For the purposes of this study, the definitions of the terms used in this study were provided as follows.

- Success criterion: a standard used for making a judgment or evaluating on success of research outcomes. It refers to a more general or broader term such as value than a success indicator.
- Success indicator: a direct method or measure that is used to evaluate of research outcomes. It refers a specific method such as a user survey or bibliometrics approach that can be used to measure a corresponding criterion.
- Process attribute: an inherent characteristic or feature that is involved with a research process. An attribute is value-neutral implying neither positive nor negative consequences.
- Success factor: an aspect or element that can influence a process attribute so as to produce a certain result

2.2 DEFINITION OF SUCCESS IN ACADEMIA-INDUSTRY COLLABORATIVE RESEARCH

2.2.1 Two modes of knowledge production

Gibbons et al. (1994) stated the advent of Mode 2 knowledge as opposed to Mode 1 knowledge as the development of science and technology has been rapidly progressing

since the 19th century. Mode 1 knowledge is theory focused and disciplinary. Knowledge production under Mode 1 is conducted within a specific discipline with specialism. The examples of Mode 1 knowledge can be found in almost every fundamental science discipline, such as physics, chemistry, biology, or mathematics. Mode 2 knowledge was born from Mode 1 disciplinary knowledge, but has been evolving across disciplines. For example, civil engineering provides a new knowledge framework completely different from traditional disciplinary sciences such as physics, geology, or chemistry. However, civil engineering could not have emerged without those traditional discipline sciences. Production of Mode 2 knowledge has been accelerated as knowledge becomes more and more "socially distributed" and even globalized triggering broader collaboration across disciplines along with the development of information and communication technologies. In addition, as knowledge started being commercialized, more and more firms became involved in the knowledge production process as a form of research and development (R&D). As a result, Mode 2 knowledge and its production no longer affect a single discipline and the researchers in that single academic community. Rather, it influences researchers, industry practitioners, and various members and organizations of a society across disciplines as well as geographical boarders.

2.2.2 Knowledge production for application

Mode 2 knowledge is produced in consideration of practical application whereas Mode 1 knowledge is produced to satisfy interests of a specific academic discipline (Gibbons et al., 1994). Accordingly, knowledge produced through academia-industry research collaboration can be viewed as Mode 2 knowledge. Gibbons et al. (1994) further defined five attributes of Mode 2 knowledge, which are application, transdisciplinarity, heterogeneity and organizational diversity, social accountability and reflexivity, and

quality control. The latter four attributes are in fact derived from the first attribute, application, which means that Mode 2 knowledge is produced "in the context of application". Since Mode 2 knowledge production aims at producing applicable solutions to be used by group, industry, government, or society, it requires transdisciplinary efforts from various organizations or groups to work on problems in a complex environment, which in turn forms the second attribute. This aspect is also closely related to the third attribute, heterogeneity and organizational diversity. Also, Mode 2 knowledge is sensitive to social impact because it purports to be applied to the real world, and therefore, the evaluation criteria of Mode 2 knowledge include academic interests as well as various perspectives of society and industry. When discussing the fifth attribute of Mode 2 knowledge production, which is quality control, Gibbons et al. (1994) indicated that the multiple criteria apply for evaluating the quality of Mode 2 knowledge incorporating different interests and perspectives of participating groups or users.

As collaborative academia-industry research produces knowledge for real world application by its nature, the five attributes described above are inherent in such research. Construction industry project management is considered as applied science combined from multi-disciplines, such as engineering, management, economics, and law (Love et al., 2002). Therefore, it is necessary to look at success of collaborative academia-industry research in construction industry project management within the framework of Mode 2 knowledge production including its five attributes described above.

2.2.3 Rigor and relevance

The gap between academic rigor and practical relevance has been addressed by the researchers in the management area (Buckley et al., 1998; Mohrman et al., 2001; Rynes et al., 2001; Starkey & Madan, 2001; Tushman et al., 2007). This gap in applied

science may be rooted from the failure to reconcile Mode 1 knowledge production and Mode 2 knowledge production. Gibson et al. (1994) pointed out that Mode 1 knowledge and Mode 2 knowledge interacts with each other. However, due to the fact that academic researchers are more familiar with the Mode 1 knowledge production, which is a traditional way of producing knowledge within a specific discipline, there can be a tendency to place greater emphasis on the familiar one than the other (Gibbons et al., 1994). Therefore, if collaborative academia-industry research can fulfill both academic rigor and practical relevance, in other words, satisfy the purposes of both modes of knowledge production, it may be considered as having potential to be successful research.

2.2.4 Outcome and impact

Pertuze et al. (2010) claimed that the important issue in industry-university research collaboration is not what such research collaboration would produce but what extent its outcomes could influence company performance. They discussed that their data showed 50% of the projects that they investigated produced outcomes which were considered as major outcomes. However, only 40% of those projects with major outcomes were perceived as having a positive impact on company performance. This "outcome-impact gap" may explain why a number of research outcomes that are viewed as interesting or valuable are not implemented well enough in the industry. This is consistent with the study by Gibbons et al. (1994). Gibbons et al. (1994) suggested that Mode 2 knowledge production is sensitive to the impact of research outcomes since the outcomes of Mode 2 knowledge production concerns a wide range of groups or organizations ("social accountability"). Thus, it is important incorporate the impact of research outcomes in academia-industry collaboration in defining its success.

2.2.5 Team approach

Another aspect that should not be overlooked in defining success in collaborative academia-industry research is the way that research is being conducted – a team approach. In collaborative academia-industry research, research participants come from different professions to do a systematic investigation trying to achieve common goals and objectives (Amabile et al., 2001). During collaboration, it is important that all research members directly contribute to all the significant research tasks throughout the research project period (Katz & Martin, 1997). Transdisciplinarity and heterogeneity and organizational diversity of Mode 2 knowledge, the second and third attributes defined by Gibbons et al. (1994), are related to the team approach of Mode 2 knowledge production. Henceforth, it is evident that the success of collaborative academia-industry research is affected by the nature of a team approach, for example, team dynamics or team composition.

2.2.6 Definition of research success

Based on the review of extant literature, this study proposes the definition of successful collaborative academia-industry research as presented below.

> *The success of collaborative academia-industry research is defined as producing research outcomes with a significant impact on participating groups or organizations delivering academic rigor and industry practicality through a scientific research methodology and collaborative team approach.*

2.3 SUCCESS CRITERIA IN ACADEMIA-INDUSTRY COLLABORATIVE RESEARCH

2.3.1 Success definition and success criteria

The second research objective is to identify collaborative academia-industry research studies that have been acknowledged as successful and less than successful. To identify these research efforts, it is necessary to establish a set of success criteria to evaluate research efforts against the success criteria. The Merriam-Webster Dictionary defines a criterion as "a standard on which a judgment or decision may be based". For example, the success criteria for a project include time, cost, safety, and quality (Lim & Mohamed, 1999). A project can be considered as successful if it achieves predefined project goals or objectives (de Wit, 1988; Lim & Mohamed, 1999), or, in other words, fulfills the predefined success criteria. Therefore, success criteria in academia-industry research collaboration need to be defined in connection with the definition of research success.

2.3.2 Multidimensionality

Gibbons et al. (1994) noted that quality assessment and quality control of Mode 2 knowledge production is different from Mode 1 knowledge production. They discussed that the evaluation criteria in Mode 2 knowledge production are much broader and complex than in Mode 1 knowledge production where the evaluation criteria are limited within the interest of a specific academic discipline. In fact, it is not unreasonable to conclude that the gap between rigor and relevance and the gap between outcome and impact in collaborative academia-industry research is partially due to the multidimensionality of success criteria – conflicts between different success criteria. Consequently, this multidimensionality of success criteria should be taken into account in defining the success criteria for collaborative academia-industry research as well.

2.3.3 Success criteria – combining success definition and multidimensionality

The key phrase of the definition of research success proposed earlier is "significant impact on participating groups or organizations". First, the success criteria should be defined focusing on "impact". This "impact" itself is multidimensional from the perspective of timeframe. Anderson et al. (2006) delved into project success criteria and success factors, and they discussed that project success criteria include both short-term and longer-term in terms of benefits that a project produces. Lim & Mohamed (1999) also categorized project success criteria into two levels; criteria at project completion and criteria at user satisfaction. The latter is longer-term assessment than the former. Henceforth, the "impact" as a success criterion should be considered from two sets of timeframe; short-term , when research outcomes are produced, and longer-term, after time has passed so that user can assess "satisfaction level".

The "participating groups or organizations" in the definition of success indicates academia and industry whether they are individual institutions and companies or academia and industry as a whole. Therefore, the success criteria should include the impact on both academia and industry reflecting both standpoints. In conclusion, the success criteria can include short-term impacts and long-term impacts from both industry and academia perspectives, which is multidimensional interpretation of "impact" in the definition of success.

2.4 CII Research – Process and Characteristics

Since the scope of this study is limited to CII research efforts in data collection, it is essential to investigate the process of a CII research team. As Halpin (2007) noted, CII has created a unique collaborative research model between academia and industry in construction industry project management. Even though several changes have been made

over time for improvement of the research process and quality, CII has maintained a formal research process for more than 30 years. Therefore, it is expected that investigation of the CII research team process can provide a theoretical framework for studies on collaborative academia-industry research.

In following sections, the overall process of a typical CII research team from research topic generation to report out will be discussed. The dissemination and implementation processes of the outcomes of individual research teams will also be presented. Then, the characteristics of the CII research team process will be explored to provide insight of the CII research team process.

2.4.1 CII research process

This section will briefly describe the CII research procedure. A typical CII research study is conducted using the following steps; research topic idea generation → pre-qualification of academic principal investigators on candidate topics → topic selection by the CII Board of Advisors → research team staffing and kick off → conduct of the research → publishing of research products and report out at the CII Annual Conference. This study focuses on the research team process, a series of research steps shown by the shaded area depicted in Figure 2-1.

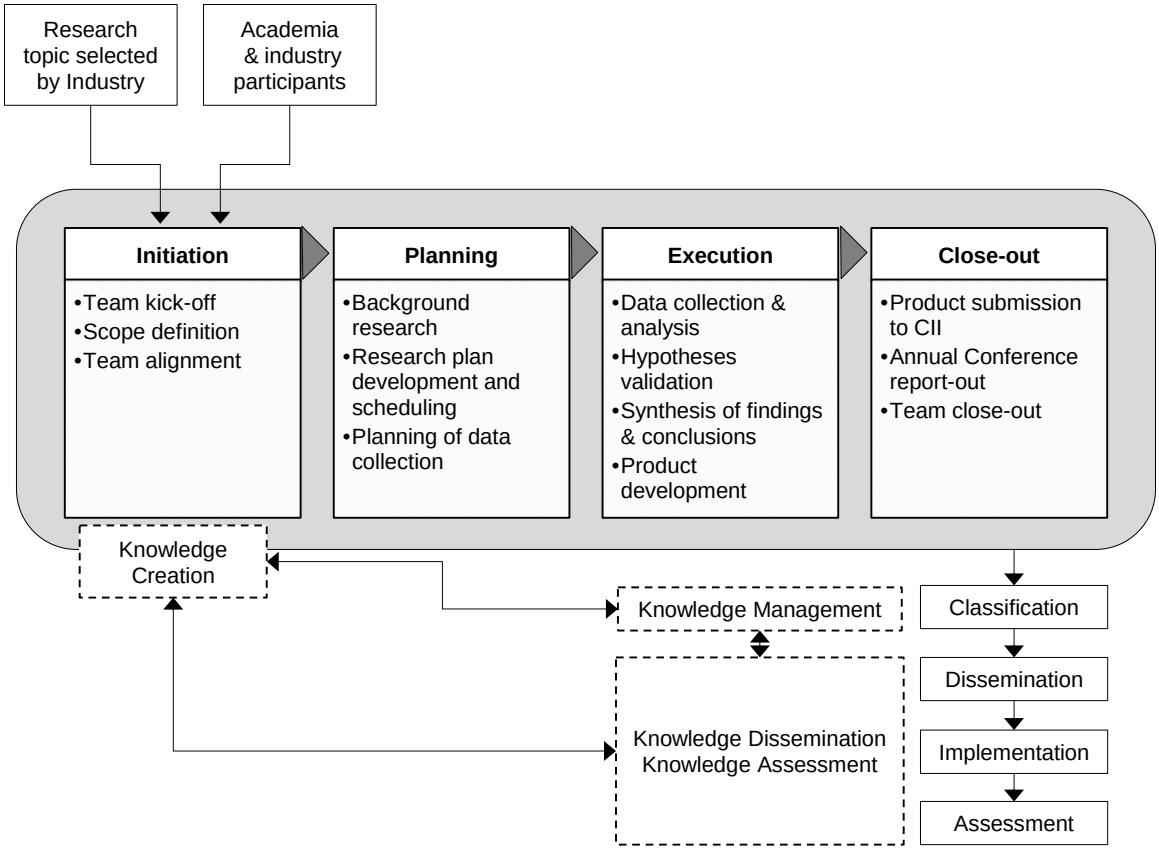


Figure 2-1: Research Process of a Typical CII Research Team

Each research team is typically comprised of one or two principal investigators from academia and a maximum of twenty industry practitioners from CII member companies. Chair(s) of each team are selected from industry team members to provide industry leadership. After conducting the research, each research team is required to produce at least one research summary and one research report to document the research outcomes. CII research teams may also produce an implementation resource if appropriate (CII, 2012; CII, 2013; CII website).

During the initiation phase, a research team defines its research scope based on the research topic provided by CII, and team members are aligned around the research

scope, objectives, and research direction. Once the team agrees on the scope, the team members conduct background research as necessary and develop the overall research plan and the data collection plan as well as brainstorm potential research deliverables. In the execution phase, the academic researchers (i.e., Principal Investigators) collect and analyze data with input from the industry team members. As the team synthesizes the findings and generates conclusions, the team packages their research outcomes into research products. As the final step, the team, submits the research products (i.e., research summary, research report, implementation resource) to CII, presents its findings, conclusions and products to the CII member companies in the CII Annual Conference, and closes out.

Research products submitted by each research team are scrutinized by the Product Review Board and the CII Knowledge Management Committee, for categorization into 60 Focus Areas of CII Knowledge Structure (see Appendix A for CII Knowledge Structure and CII Research Teams in each Focus Area). The purpose of this classification system is to provide easy access to CII products, and therefore, to support the implementation efforts of CII member companies. The classification also enables assessing research needs (CII website; Kim & Gibson, 2002).

Once the research products are filed in the CII Knowledge Structure and made available both hardcopies and online, CII member companies can purchase or download those products for the dissemination and implementation purposes. To facilitate the dissemination and implementation efforts of the member companies, CII offers various resources, such as Performance Improvement Workshops or the Implementation Roadmap, sponsored by the CII Implementation Strategy Committee. Each member company designates a CII Implementation Champion, an individual or team who takes

the lead role of implementing CII research findings. CII provides an assessment system where each member company can measure the level of implementation of select CII research identified as best practices and the performance of their capital project in comparison with others (CII website). CII also assesses the value of its research outcomes recognized by the member companies through periodic surveys as well as its benchmarking program (CII, 2011).

2.4.2 Characteristics of a CII research team

Since this study focused on the CII research team process as a model of academia-industry research collaboration, it was necessary to understand the uniqueness of the research process of a typical CII research team. The unique characteristics of CII research process include industry leadership of a research team, a high level of industry member participation in the research team process, the emphasis on using a scientific research approach, and producing research deliverables for an industry use.

The most distinct facet that differentiates a CII research team from other collaborative academia-industry research teams is that the overall leadership of a research team is provided by industry team members. The 'Roles and Responsibilities for the CII Research Process' section in the Request for Qualification document (CII, 2013) well depicts this aspect. The expected roles and responsibilities of industry members and academic researchers. The document states that "overall team leadership" is provided by the team chair who is appointed from industry team members whereas academic researcher(s), called Principal Investigator(s) "guides the team's research activities". In case of non-CII collaborative academia-industry research teams, often academics take a leading role (Amabile et al., 2001; Schubert & Fisher, 2009), a notable distinction for CII research.

A second distinct feature is the level of industry participation in CII research activities. This significant level of industry involvement can be found in the number of industry members participating on a research team, and in the roles of industry members expected by CII. First, the average number of academic researchers on 84 research teams from 2004 through 2013 is 2. In comparison, an average of 14 industry member has participated on each research team of those 84 research teams. Considering a simple ratio of 1 to 7 for academics to industry members, it is apparent that industry participation and contribution is an essential part of CII research. Moreover, the 'Roles and Responsibilities for the CII Research Process' in the Request for Qualification document (CII, 2013) specifies that industry team members are expected to write the research summary, one of research deliverables that a team is obliged to produce. This document also encourages active participation and "intellectual contributions" of industry team members to the research activities.

The third characteristic is that CII emphasizes the use of the scientific methodology. The CII Quality Research document (CII, 2011) states that the research should be performed in the classic research mode with use of scientific methodology. This emphasis shows that CII well recognizes the importance of the academic rigor in its research.

The fourth characteristic is found in CII's requirements in regard to research deliverables. The mandatory deliverables of each research team are a research summary and research report. The target audience of the research summary is industry practitioner, and, therefore, it is produced by a team effort with the participation of the industry team members. The research report is an academic report depicting the whole research process, much resembling a doctoral dissertation, and is submitted to CII from the PIs' institutions.

In addition to these two required deliverables, a research team may develop an implementation resource which purports to provide a guide or tool for the member companies in implementing the research findings or recommendations (CII, 2012). These deliverables of each CII research team are published both online and hardcopies, and are presented in the CII Annual Conference. This unique characteristic of CII research enables both immediate dissemination and long-term accessibility of research outcomes and facilitates implementation of such outcomes.

2.5 SUMMARY

This chapter presented the review of extant literature to address success and success criteria for collaborative academia-industry research. From the literature review, the definition of research success was proposed in the attempt to achieve the first research objective. The chapter also provided a discussion on the success criteria closely related to the definition of success. Next, the chapter presented an overview of the CII research process and characteristics to understand the process of a typical CII research team as well as to interpret the CII's process within the context of success and success criteria of collaborative academia-industry research.

Chapter 3: Conceptual Research Framework

The purpose of this chapter is to suggest the conceptual research framework. The conceptual research framework was developed on the basis of the review of the literature as well as the CII research process and characteristics discussed in the previous chapter. Then, this chapter discusses a set of research propositions from literature review in connection with conceptual research framework.

3.1 Development of Conceptual Research Framework

3.1.1 Definition of success and success criteria

The purpose of the conceptual research framework is to illustrate constructs, factors, or variables and their relationships to be studied in research (Miles & Huberman, 1994). In the previous chapter, success of collaborative academia-industry research and the success criteria were defined. Success was defined as "producing research outcomes with a significant impact on participating groups or organizations delivering academic rigor and industry practicality through a scientific research methodology and collaborative team approach." The success criteria were defined as short-term and long-term impact of research outcomes on the industry and the academia. The previous chapter also discussed the process and four characteristics of a typical CII research team. Based on those definition and discussions, a conceptual research framework was developed as illustrated in Figure 3-1.

Inputs of the CII research process include; 1) the research topic and the essential question, which are developed by the industry, and 2) academic researchers and industry members for team formation. The research process consists of three components, research methodology, team dynamics, and product design and development. These

components characterize the CII research process and define the boundary of research activities. The outputs of the research process, the research products published by CII, are distributed to the industry as well as the academia. CII promotes dissemination and implementation of such research outcomes packaged in a form of research products through various resources and by the efforts of the standing committees, for example, the Implementation Strategy Committee. The value of CII Best Practices is periodically assessed by CII as well. Therefore, in this conceptual research framework, the success criterion (i.e. impact) is translated into dissemination, implementability, and value within the context of CII research.

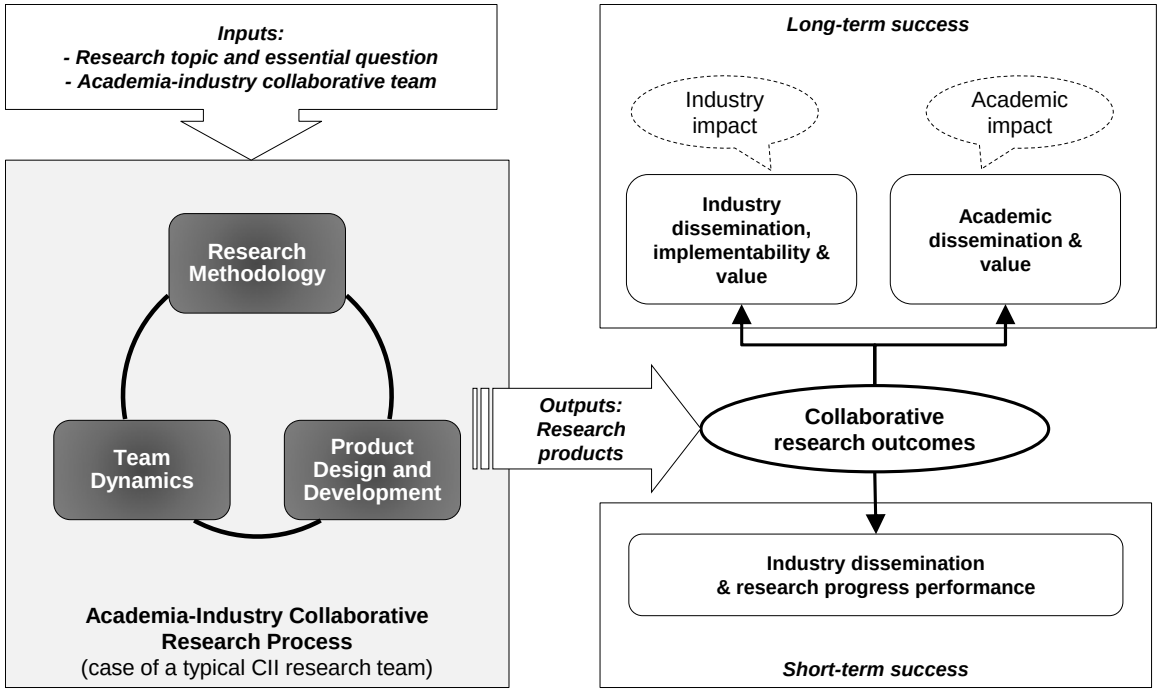


Figure 3-1: Conceptual Research Framework

As discussed earlier, since the success criteria are multidimensional by timeframe and associated groups, these criteria, dissemination, implementability, and value are

further divided into industry and academic as well as long-term and short-term criteria. The first short-term criterion is immediate industry dissemination when the research outputs are produced. The research progress performance of a team was added as the second criterion for short-term success from the perspective of research management.

The short-term success criteria for academia are not defined. The success of a certain research outcome from the academic perspective is judged by academic peers in terms of its contributions to academic and intellectual body of knowledge (Gibbons et al., 1994). Academia-industry collaborative research involves individual researchers and practitioners from company organizations, and it defines its target audience in the industry side (e.g., collaboration partner firms, industry types, etc.) clearer than its target audience in the academia side. The collaborative research outcomes will be disseminated and implemented by participating industry company organizations faster than by the academia where the individual researchers who performed such collaborative research should produce academic journal articles and peer researchers review them to determine its impact and contribution. Therefore, the scientific impact of such research quality is not readily assessable in short-term.

The long-term success criteria are defined as dissemination, implementation and value for the industry, and dissemination and value for the academia. Dissemination here refers the longitudinal assessment of dissemination of research outcomes rather than immediate dissemination of research outputs (i.e., research products). For the academia, implementability is not considered as a success criterion since implementability is the criteria use to evaluate applicability of research to the industry issues and problems.

The focus of this study, the collaborative academia-industry research process is the shaded part of Figure 3-1. The key success factors to be investigated were limited to

the three facets, research methodology, team dynamics, and product design and development. The next section will address the success factors of academia and industry collaborative research based on the literature review focusing on these three facets.

3.1.2 Success factors for collaborative academia-industry research

This section provides the literature review in regard to success factors of collaborative academia-industry research. The first part is the review of the CII Quality Research Document developed by the CII Research Committee. The second part is the review of the previous studies focusing on success factors for collaborative academia-industry research.

3.1.2.1 CII Quality Research

The CII Research Committee commissioned a subcommittee for an in-depth examination on CII research quality and its process in July 2009. The subcommittee, consisting of five members and the Associate Director for CII Research, developed a document defining criteria and characteristics that the subcommittee considered as those of quality research. Upon review by the whole committee, the document, Quality Research Document, was finalized and approved as guidance to CII research teams. This document is provided in Appendix C. The six criteria and key characteristics described in the Quality Research Document are summarized in Table 3-1.

Criteria	Key Characteristics
1. Topic addresses a valid industry concern.	• High value/impact topic • Precise essential question • Relevancy of topic • Innovativeness
2. Research is competently done in the CII mold.	• Committed members of a joint venture between industry and academia • Clear and consistent • Breakthrough thinking • Team participation • Roles and responsibilities of academics and industry • Team alignment and understanding around the research methodology ensuring quality and quantity of data
3. Research is performed in the classic research mode.	• Scientific research methodology: "Problem/Question → Hypothesis → Data Collection/Analysis → Validation → Implementation Guidance" model • Appropriate research methods
4. The research and products answer the "essential question".	• Product validation • Fact -based data • Innovativeness • Various perspectives • Implementability
5. The research and products are of value to the CII membership.	• Readily implementable • Replicable data & analysis • Timely solution
6. The research and products contribute to the storehouse of knowledge.	• Delivery of required products • Published in journals/conference papers • Teachable in to students

Table 3-1: Criteria and Key Characteristics of Quality Research (CII, 2010)

3.1.2.2 Success factors for collaborative academia-industry research

The previous studies on the success factors for collaborative academia-industry research were closely reviewed. The success factors found in the previous studies were first organized into, research methodology, team dynamics, and product design and development; the three components of the conceptual research framework in Figure 3-1. Then, the success factors were further grouped and categorized. Table 3-2 presents the factors by categories and the three components.

The categories for research methodology include research scoping and design, research methodology, data collection and analysis, and innovativeness. Team dynamics includes 4 categories, which are alignment, team member participation and commitment, academia-industry collaboration, and leadership. Usability is the category for product design and development. The success factors identified in the Quality CII Research document (CII, 2010) and those previous studies were reviewed to develop research propositions that will be discussed in the next section.

Category Level 1	Category Level 2	Success factors	Previous studies
Research Methodology	Research scoping & design	Clearly established research problem	CII (2010); Kulatunga et al. (2011)
		Clearly defined objectives and mission	Barnes et al. (2006); Littler et al. (1995); Mora-Valentin et al. (2004); Pinto & Covin (1989)
		Project feasibility	Kulatunga et al. (2011)
	Research methodology	Scientific and classic research approach	CII (2010)
		Research approach made clear to the practitioners	Werr & Greiner (2008)
	Data collection & analysis	Objective and validated data	CII (2010); Lucko and Rojas (2010)
		Various data collection methods	Abowitz & Toole (2010); Amaratunga et al. (2002); Azhar et al. (2010); CII (2010); Green et al. (2010); Love et al. (2002)l; Phelphs & Horman (2010); Sillars &Hallowell (2009)
	Innovativeness	Creativity, breakthrough thinking, innovativeness	CII (2010)

Table 3-2: Success Factors of Academia-Industry Collaborative Research – Literature Review

Category Level 1	Category Level 2	Success factors	Previous studies
Team Dynamics	Alignment	Jointly agreed and consistent objectives & vision	Butcher & Jeffrey (2007); Davenport et al. (1999); Shubert & Fisher (2009); Stokols et al. (2008)
		Establishment of clear and realistic goals	Barnes et al. (2006); Kulatunga et al. (2011)
		Shared research framework/ methodology	CII (2010); Kishchuk (2005)
		Conflicts resolution	Amabile et al. (2001); Mora-Valentin et al (2004);
	Participation & commitment	Constant engagement and involvement, continuity	Barnes et al. (2006); Butcher & Jeffrey (2007); CII (2010); Kishchuk (2005)
		Commitment	Barnes et al. (2006); Butcher & Jeffrey (2007); Davenport et al. (1999); Kulatunga et al. (2011); Littler et al. (1995); Mora-Valentin et al. (2004); Stokols et al. (2008)
	Leadership	Leadership and leader skill	Amabile et al. (2001); Davenport et al. (1999); Sicotte & Langley (2000); Stokols et al. (2008)
		Leadership of academics	Kulatunga et al. (2011)
	Academia-industry collaboration	Interaction, integration, cooperation and collaboration	Amabile et al. (2001); Barnes et al. (2006); Butcher & Jeffrey (2007); Kishchuk (2005); Stokols et al. (2008); Kulatunga et al. (2011)
		Clear allocation of roles, responsibilities and expectations	Amabile et al. (2001); Barnes et al. (2006); CII (2010); Davenport et al. (1999); Kulatunga et al. (2011); Littler et al. (1995)
Product Design & Development	Usability	Usable and implementable	CII (2010); Shubert & Fisher (2009)

Table 3-2, continued.

3.2 RESEARCH PROPOSITIONS

Developing research propositions is particularly important in qualitative research. The propositions are the 'tentative answers' to the research questions, and compared and are examined with findings from data collected and analyzed (Maxwell, 2005). Propositions also provide guidance in the research direction and set a boundary of data collection in case study research (Yin 2009). The propositions for this study, therefore, were developed to guide the data collection and analysis process.

The process of a collaborative academia-industry research team is considered to have three facets; research methodology, team dynamics and product design and development as discussed earlier. Based on the review of the CII Quality Research document and extant literature (see Tables 3-2 and 3-3), a total of 11 propositions were developed for each of these three aspects. The propositions developed in this study represent the 'ideal type' of successful research in terms of research methodology, team dynamics, and product development in a collaborative academia-industry research setting. This 'ideal type' is a theoretical basis that a successful research team is expected to be, and, therefore, it is the standard against which the data were analyzed and compared (de Vaus, 2001). The following sections will discuss the propositions in detail.

3.2.1 Research methodology

Developing proper research methodology is an essential and critical part of research. Particularly, in applied science research where balancing academic rigor and practicality is required, the importance of establishing appropriate research methodology increases. Previous studies on collaborative academia-industry research illustrate this importance of research methodology as shown in Table 3-2. Thus, six propositions were developed in association with research methodology of collaborative academia-industry

research. These six propositions address research scoping, design, methodology, data collection, data analysis, and innovativeness, respectively.

3.2.1.1 Research scoping and design

Kulatunga et al. (2011) attempted to develop a performance measurement system for a collaborative construction R&D project. Their study defined critical success factors in each phase of a collaborative R&D project. They found that "establishing the research problem clearly" was the most critical success factor in a project initiation phase of construction research collaboration between academia and industry. In a project conceptualizing phase, their study results indicated that "check the feasibility of the project" was the most critical factor and "establishing clear and realistic goals/deliverables/milestones" was the fourth critical factor among 17 factors. Barnes et al. (2006) also asserted that "clearly defined objectives", "mutually agreed project plan" and "defined project milestones" are some of important factors to collaborative R&D projects. The Quality CII Research document (CII, 2010) states that a CII research team "pursues clear and consistent objectives". These previous studies illustrate well the importance of scoping in collaborative academia-industry research. Therefore, the following propositions were developed in regard to research scoping from the research methodology perspective of a successful research team.

Proposition (1): The research scope is well defined and clearly addresses the topic and research question within the time and cost constraints of the study.

Proposition (2): The research plan, methodology, and data collection methods are well designed and thus, properly explored the topic and answered the research question.

3.2.1.2 Research methodology, data collection methods and data analysis

The Quality CII Research document (CII, 2010) defines "classic research mode" as one of criteria for quality CII research. The document addressed that the research 'methodology follows "Problem/Question→Hypothesis→Validation→Implementation Guidance", which implies that the CII research process should be a traditional scientific process. The document also defined solid and doable methodology, research methods relevant to the essential research question, clear and appropriate data and analysis as some characteristics of quality research in terms of research methodology.

Numerous studies have addressed the research methodology issue in construction management research. Abowitz and Toole (2010) and Amaratunga et al. (2002) suggested a mixed method of qualitative and quantitative techniques as a prominent research approach to improve quality and enhance reliability and validity of research in construction research. Sillars and Hallowell (2009) studied four techniques that are typically used in opinion-based research in search for alternative research methods to take into account the diversity of the construction environment. Phelphs and Horman (2010) investigated the ethnographic theory building approach in attempt to reflect social and technical aspects of the construction industry. Azhar et al. (2010) proposed the action research method and Green et al. (2009) suggested a grounded approach to reduce the gap between academic rigor and practical relevance in construction research. Lucko and Rojas (2010) asserted that the importance of research validation in ensuring the research quality, and explored research validation and its challenges in construction research. These previous studies commonly seek diversification of research methods in construction research while emphasizing the importance of selecting a 'right' method for

a given research problem and question. Thus, 3 propositions were developed as presented below.

Proposition (3): The methodology follows the "Problem/Question → Hypothesis → Data Collection/Analysis → Validation → Implementation Guidance" model or an appropriate variation of this model.

Proposition (4): The data collection methods are developed to adequately support the research topic and objectives.

Proposition (5): Data and analyses are objective and adequate for the testing and validation of the hypothesis.

3.2.1.3 Innovativeness

The last proposition for research methodology is related to innovativeness. The CII Research Committee has strongly advocated the importance of innovative research. The Quality CII Research document (CII, 2010) emphasizes creativity in data collection and research methodology producing breakthrough outcomes. Thus, the sixth proposition was developed as follows.

Proposition (6): The research process encourages breakthrough thinking.

3.2.2 Team dynamics and management

Academia-industry collaborative research is conducted by a team comprised of single or multiple academic researchers and a number of industry practitioners unlike academic-alone research or company in-house research and development. Industry members of a typical CII research team are from different companies rather than a single company. This unique feature, expressed as the "CII mold" in the Quality CII Research document (CII, 2010), inevitably brings interpersonal and intrapersonal issues during the research process. Henceforth, the second set of research propositions deal with this team

dynamics and management aspect in the research process. Four propositions were developed referring to team alignment, team commitment and participation, leadership, and collaboration, respectively.

A number of researchers have pointed out team and personal factors among others in terms of research collaboration success. Amabile et al. (2001) investigated determinants of research success in academic-practitioner collaboration in management research. They found leader skill, compatibility of problem-solving styles and cultural compatibility as key determinants for the collaborative team. Barnes et al. (2006) developed a model for R&D collaboration, particularly between academia and industry. In their model, cultural compatibility, mutual understanding, high quality staff, complimentary expertise, collaborative experience, and complimentary aims are included as success factors from the aspect of research partner selection. Their model also defines leadership, mutual trust, commitment, teamwork, personal relationship, flexibility, and learning as "universal success factors" which concerns the whole research process. Littler et al. (1995) studied contributing factors that affect success of collaborative product development. They identified success factors in 7 categories. Among those, culture, mutual understanding, complimentary expertise and strengths, and past collaboration experience are factors in partner selection, and communication and mutual trust/openness/honesty are key process factors. Commitment of both participants and top management and personal relationship were also pointed out as people factors in their study.

Kulatunga et al. (2011) defined a set of critical success factors in a collaborative construction R&D project including leadership and commitment of the principal investigator, commitment of team members, clarity and focus of work, and clear and

realistic goals/deliverables/milestones are addressed as important factors. In the report to assess major collaborative research initiatives of Social Sciences and Humanities Research Council of Canada, Kishchuk (2005) found that successful collaborative research projects have common characteristics such as shared research methodology and framework among team members, encouragement of team member participation and engagement, communication of clear expectations, and high level of member interaction. Stokols et al. (2008) studied factors of effectiveness of a transdisciplinary collaborative team. They found that team members' attitude and values, collaborative readiness, willingness to commitment, collaborative experience and quality of leaders are key 'intrapersonal' factors. In terms of key 'interpersonal' factors, the study addressed communications and consensus, diversity, learning and cohesiveness/flexibility/openness.

The CII Research Committee also emphasized team characteristics in the Quality CII Research document (CII, 2010). The team-related characteristics defined in the document include commitment and constant participation of team members, and effective meeting operation to enhance collaboration between academia and industry. The document emphasizes the attitudes, respective roles and responsibilities, and expected contributions of industry members and academic researchers. In addition, shared understanding and commitment of team members to the research direction and methodology to achieve the research objectives are addressed as well.

The review of extant literature and the CII document indicate that common factors of collaborative research success include shared understanding and consensus of the research plan and direction, leadership, commitment and participation of members, communication, interpersonal relationship and attitude, and prior collaboration

experience. Based on the literature review, four propositions were developed for the team dynamics and management category as shown below.

Proposition (7): The team is well aligned around research objectives and methodology.

Proposition (8): The team members are committed and actively participated in the research throughout the research process.

Proposition (9): The leadership provided by the team chair(s) inspires member participation and commitment, and is integral to the team's success.

Proposition (10): Academic and industry team members clearly understand their respective roles and responsibilities, and the research effort reflects their synergistic collaboration.

3.2.3 Product design and development

A research product is a form of communicating research findings and conclusions (i.e., research outcomes) with users. The Quality CII Research document (CII, 2010) addresses several characteristics of quality research in regard to research products. The document specifies that the product of a CII research team must answer the essential research question and bring value to the CII member companies. The document further requires that the research product facilitates breakthrough thinking, considers various perspectives and provides readily implementable and timely solution to the industry. Considering that collaborative academia-industry research is Mode 2 knowledge production, it is important to deliver findings and solutions applicable to industry.

Proposition (11): The research product provides clear and practical guidance for implementation, as appropriate, and is easy to understand and ready to use.

3.3 SUMMARY

In the previous chapter, the definition of success and success criteria were proposed based on the literature review, and the CII research process and characteristics were also closely reviewed. Based on these, this chapter discussed the development of the conceptual research framework to identify the subjects and their relationships of this study. Built on the conceptual research framework, the 11 research propositions, which describe the attributes of a hypothetical "ideal type" successful collaborative academia-industry research team, were developed through extensive review of the relevant literature to delimit this study and to guide the development of the research methodology.

Chapter 4: Research Methodology

The research methodology of this study consists of six phases as illustrated in Figure 4-1. Each of these six phases is discussed in detail in the following sections.

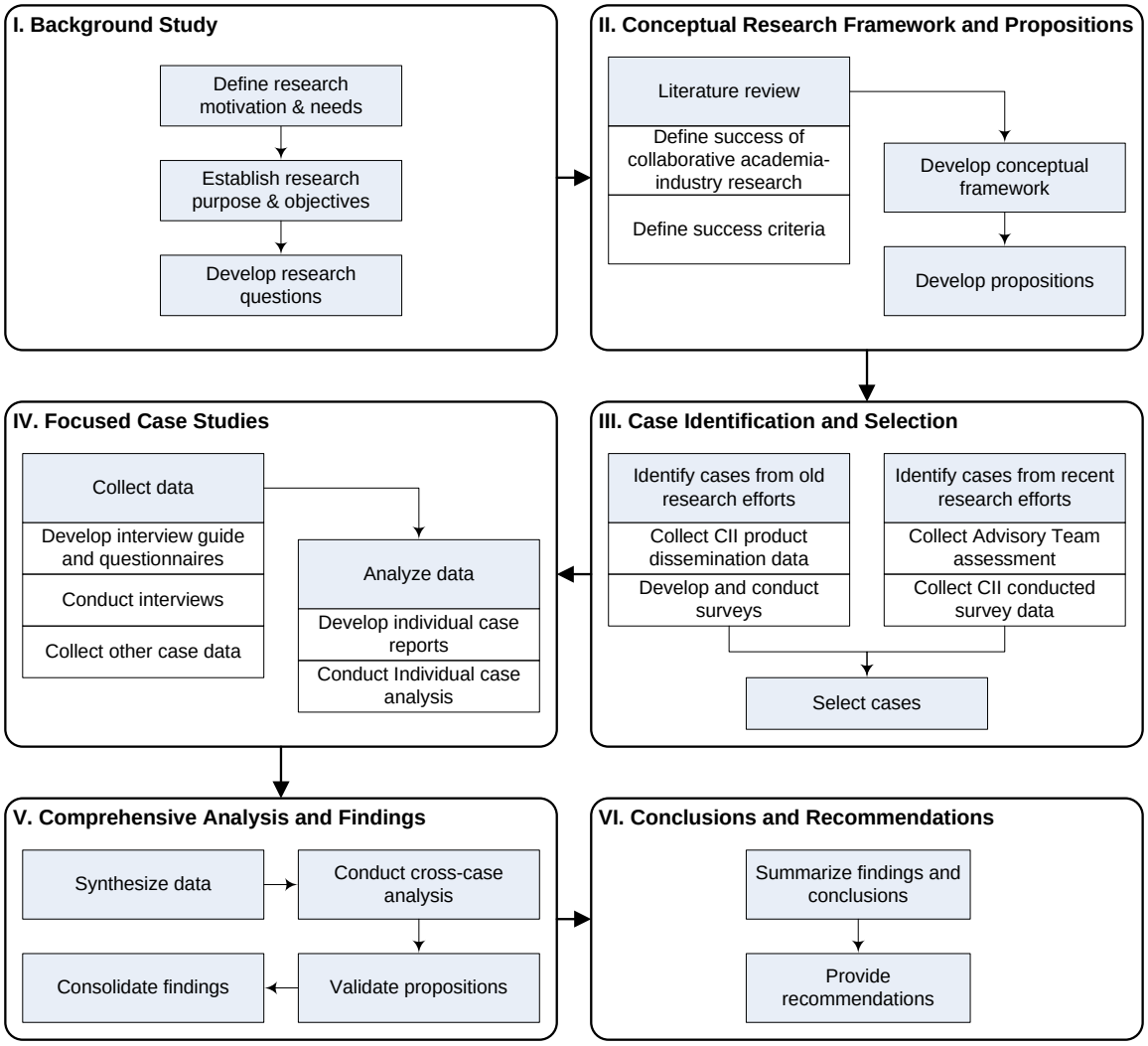


Figure 4-1: Research Methodology

4.1 PHASE I: BACKGROUND STUDY

In the first phase, the research motivation and needs were identified from the initial literature review. Then, the research purpose and objectives were established, and the research questions were developed.

4.2 PHASE II: CONCEPTUAL RESEARCH FRAMEWORK AND PROPOSITIONS

In this phase, the success of collaborative academia-industry research was defined and proposed from the literature review in the attempt to achieve the first research objective. In addition, the success criteria were also identified in relation to the definition of such research success. Next, the conceptual research framework, where research constructs and their relationships were defined, was developed. The framework clarified the boundary of this study as well as the subjects of data collection and analysis. Within the context of this conceptual research framework, the 11 propositions were suggested based on the review of extant research studies.

4.3 PHASE III: CASE IDENTIFICATION AND SELECTION

The main purpose of this phase was to identify and select appropriate CII research efforts for focused case studies achieving the second research objectives with the answers to the second research question. CII research efforts were assessed using success indicators against the success criteria, which were defined in the conceptual research framework in Phase II. The candidate cases were derived from the research efforts, which were evaluated as successful and less than successful. The cases were selected from two groups, the old CII research efforts and the recent CII research efforts. Separate data collection and analysis process was applied for each group. Product dissemination data were collected and two types of surveys were developed and distributed to assess old research efforts. To evaluate recent research efforts for selection of cases, the Advisory

Team provided their assessment and surveys. After completing data analyses, a total of 11 research efforts were selected as cases for focused case studies.

4.4 PHASE IV: FOCUSED CASE STUDIES

This phase included in-depth investigations of the cases selected from Phase III in an attempt to distinguish key research process attributes of research success. The primary data collection method for the focused case studies was individual interviews with the research team participants of the 11 cases. A total of 39 individuals who participated on the case research teams were interviewed in person or via phone (including internet calls) using detailed interview questions formulated from the literature review and the research propositions. Other data related to the cases, such as team documents and relevant CII archival records, were also collected to supplement individual interview data. With the completion of data collection, an individual case report was developed for each of 11 cases. These case reports summarized all the data collected for each case, and the data were reduced and organized to validate data across various sources. The individual case reports were used as a database for cross-case analysis in the next phase.

4.5 PHASE V: COMPREHENSIVE ANALYSIS AND FINDINGS

The fifth phase of the methodology was a cross-case analysis across the 11 cases. The main analysis methods were content analysis and pattern analysis to identify any common or peculiar features that emerged across all 11 cases or parts of the 11 cases. The research propositions proposed in Phase II were validated against the findings derived from the cross-case analysis. This phase was the process used to achieve the third research objective by answering the corresponding research question.

4.6 PHASE VI: CONCLUSIONS AND RECOMMENDATIONS

The final phase summarized the findings and conclusions of this study. Limitations of this study and recommendations for future research were also proposed.

Chapter 5: Case Identification and Selection

This chapter describes Phase III of this study, identification and selection of CII research efforts for use in Focused Case Studies. This phase was also an effort to achieve the second objective of this study by answering the second research question. The second objective of this study is 'To identify and investigate collaborative academia-industry research studies that have been acknowledged as successful and less than successful by both industry and academia'. The research question formulated to achieve this objective is 'What are the indicators of research success?'

5.1 OVERVIEW

It was important to establish an appropriate data collection and analysis process to effectively assess CII research efforts so that successful and less than successful research efforts were identified as final cases for Focused Case Studies. From the conceptual research framework presented in Figure 3-1 in Chapter 3, the success of collaborative academia-industry research needs to be evaluated from long-term and short-term as well as industry and academia perspectives. In this chapter, a set of success indicators were defined to assess the research efforts against those success criteria. Then, data were collected by the success indicators and analyzed to pinpoint potential research efforts for Focused Case Studies.

5.1.1 Success indicators

The success criteria were categorized into long-term and short-term criteria, and the long-term success criteria were further divided into industry and academia success criteria. The long-term success criteria defined are dissemination, implementation, and value for industry and dissemination and value for the academia. The short-term success

criteria are dissemination and research progress performance from the industry perspective. To assess research efforts against these success criteria, it was necessary to define proper indicators or evaluation methods for each success criterion.

A number of previous studies discussed the indicators for evaluating research performance and quality. Those indicators include survey, case study, econometric analysis, sociometric analysis, bibliometric analysis, document analysis, user evaluation, historical tracing, field visit, and expert judgment including peer review and benchmarking (Boaz et al., 2009; Committee on Science, Engineering, and Public Policy, 1999; Kosstoff, 1996; Ruegg and Feller, 2003).

Since this study identified multiple success criteria of collaborative academia-industry research, it was decided to use multiple success indicators accordingly. The previous studies also recommended to select appropriate indicators within the context of research to be evaluated and suggested using multiple indicators rather than a single method for triangulation of evaluation results (Boaz et al., 2009; Ruegg and Feller, 2003). After scrutinizing the advantages and disadvantages as well as data availability and accessibility, survey, bibliometric citation analysis, and expert judgment approaches were selected among others as research success indicators for the purposes of this study. Table 5-1 summarizes these selected indicators with their advantages and disadvantages.

First, a survey method was selected for assessment about dissemination, implementation, and value of the CII research efforts. By this approach, it was expected to obtain the perceptions of actual users as well as producers (i.e., practitioners of the CII member companies and academics) of the research efforts. Next, a citation analysis method was selected to evaluate research quality and impact from the academic viewpoint.

Indicators	Description	Advantages	Disadvantages	Sources
Survey	• Asking multiple stakeholders a set of pre-defined questions about specific topics such as accomplishments or value	• Providing both quantitative data and qualitative • Relatively inexpensive	• Potential bias depending on respondents • Limited to obtain information on individual research effort	• Boaz et al. (2009) • Ruegg and Feller (2003)
Bibliometrics – citation analysis	• Assessment of research impact by counting the number of citations	• Quantitative analysis • Relatively simple and straightforward • Relatively economical because of using existing databases	• Time lag exists until citations become available • Difficult to directly assess quality of research outputs • Difficult to compare across disciplines	• Boaz et al. (2009) • Committee on Science, Engineering, and Public Policy (1999) • Kosstoff (1996) • Ruegg and Feller (2003)
Expert judgment	• Assessment of research quality using opinions and judgment of experts	• Relatively straightforward and cost-effective • Providing qualitative assessment	• Difficult to identify qualified experts • Potential biases of experts • Limited to qualitative assessment	• Boaz et al. (2009) • Committee on Science, Engineering, and Public Policy (1999) • Ruegg and Feller (2003)

Table 5-1: Advantages and Disadvantages of Success Indicators

An expert judgment approach was selected to evaluate the research progress performance since the CII Research Committee has monitored the research efforts over many years and has sufficient expert knowledge about CII research efforts. Finally, product usage data analysis was added to assess dissemination of the research efforts. This approach was unique to CII research, since the research products produced by the CII research teams have been available for over 30 years for purchase or downloads, and CII has been keeping the sales and download records. These success indicators and the associated success criteria are summarized in Table 5-2.

Timeframe	Users	Success criteria	Success indicators
Long-term	Industry	• Dissemination • Implementation • Value	• Industry product usage • Industry user perception survey • Industry user perception survey
	Academia	• Dissemination • Value	• Academic citation analysis • Academic perception survey
Short-term		• Dissemination • Research progress performance	• Initial product usage • User perception survey • Expert judgment • Research participant survey

Table 5-2: Research Success Criteria and Success Indicators

5.1.2 Data collection and analysis process

To encompass the multidimensional success criteria and indicators shown in Table 5-2 in the data collection and analysis, a dual data collection approach was formulated as illustrated in Figure 5-1. The CII research efforts that reported out before 2009 were considered as “old” research efforts based on the assumption that the products

of those research efforts had been available for a period of time sufficient enough to be studied and implemented by users. The old research efforts were the subjects of long-term success assessment. The research efforts that reported out from 2009 to 2011 were defined as "recent" research efforts as it was assumed that the products of those research efforts had not been exposed to users sufficiently enough to be evaluated. The recent research efforts were the subjects of short-term success assessment. In sections 5-2 and 5-3 of this chapter, the case identification and selection processes for old CII research efforts and recent CII research efforts are discussed in detail.

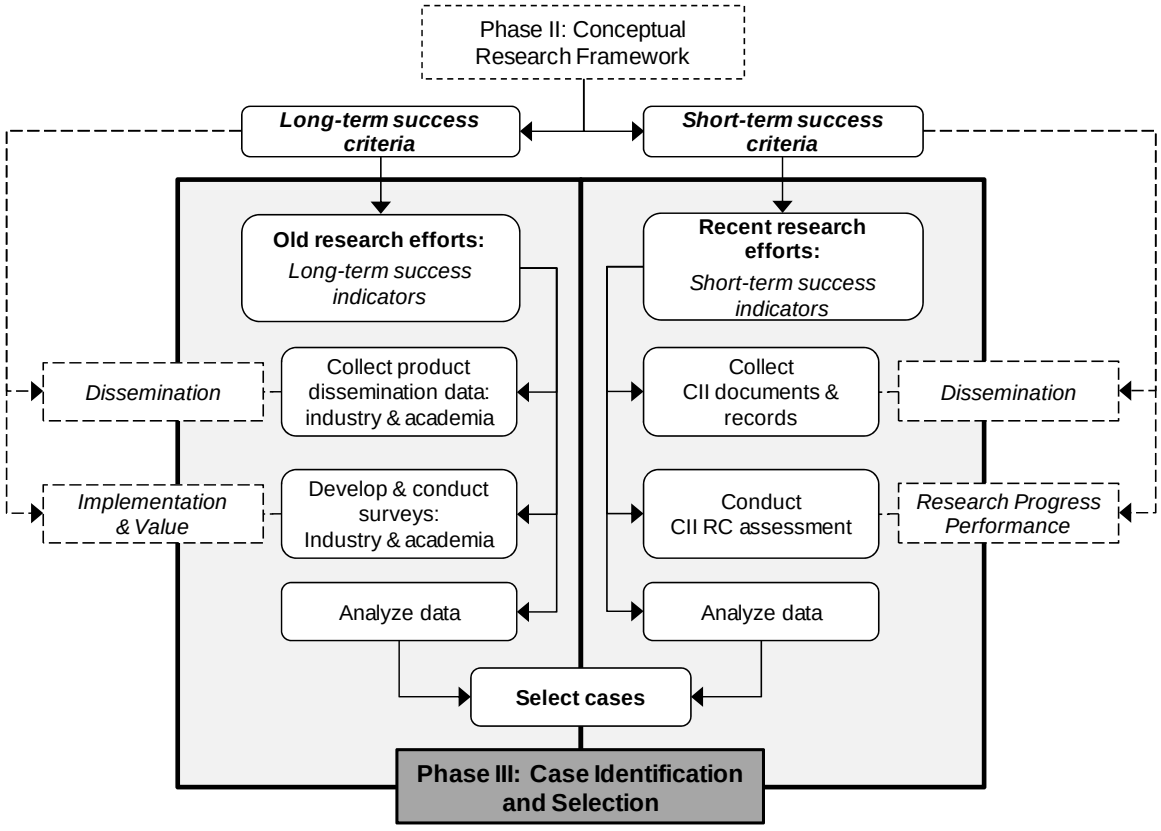


Figure 5-1: Process for Case Identification and Selection

5.2 CASE IDENTIFICATION FROM OLD RESEARCH EFFORTS

This section discusses the data collection and analysis process to identify and select candidate cases from old research efforts as shown in Figure 5-2. The first section addresses the reason for assessment of CII Knowledge Structure Focus Areas, followed by two sections which describe product dissemination assessment and survey assessment.

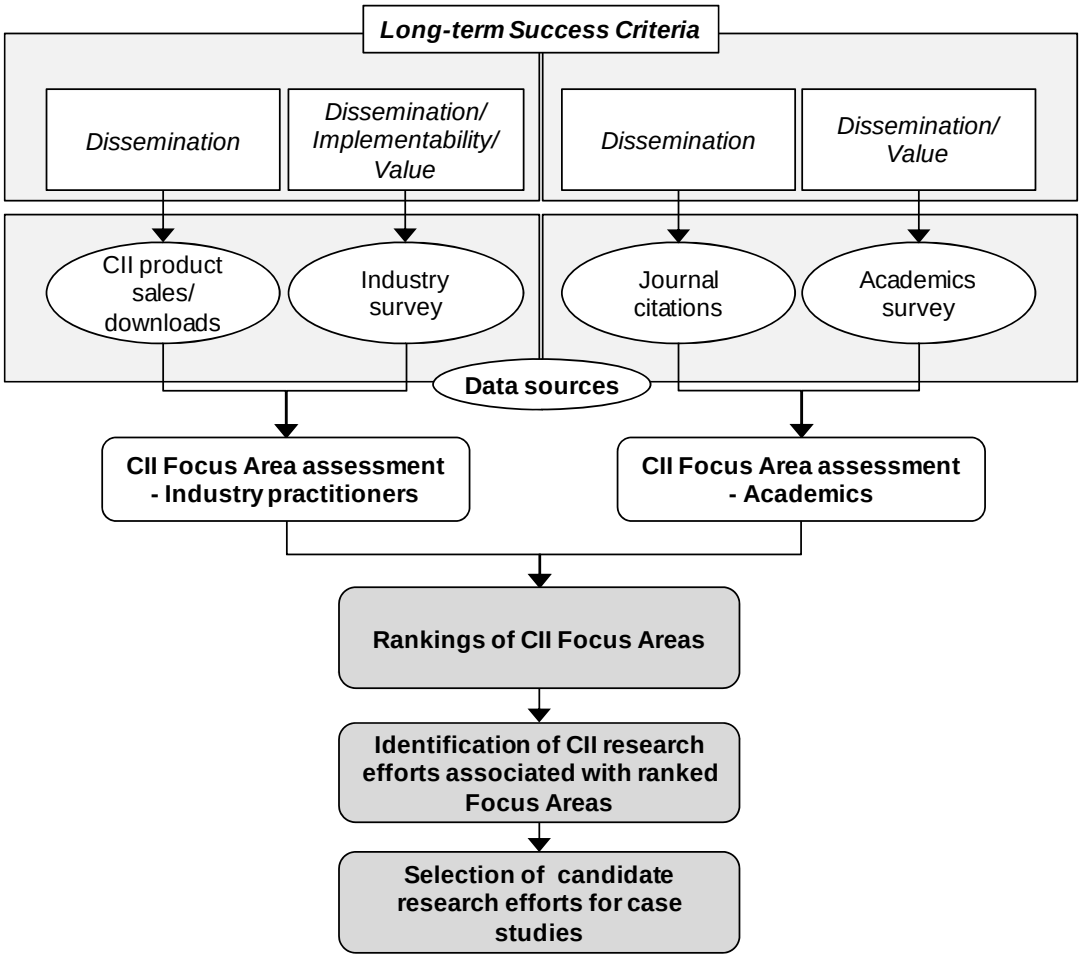


Figure 5-2: Case Identification and Selection Process for Established Research Efforts

5.2.1 Assessment of CII Knowledge Structure Focus Areas

Assessment of research efforts was conducted for CII Focus Areas categorized in the CII Knowledge Structure rather than individual research efforts (research teams). The CII Knowledge Structure is the "overall body of CII knowledge" where products of individual CII research teams are categorized into its topical areas to better facilitate the implementation of CII research products in company organizations (Kim & Gibson, 2002). The main reason for assessing individual CII Focus Areas rather than individual research efforts in this study was the number of research efforts that have been conducted by CII. More than 150 CII research projects had been completed by 2011, and over 480 products had been published from this research. Considering its magnitude, it was not practical to assess implementability and value of each of 150 research projects from industry practitioners or academic researchers. Moreover, since the CII Knowledge Structure is the access point to CII research products for users, the users are likely to be more familiar with 'practices (or Focus Areas)' rather than individual research efforts. Thus, assessment of old research efforts was conducted at a practice-level, and then corresponding research efforts were identified from the CII Knowledge Structure (refer to Appendix A).

5.2.2 Product dissemination data

5.2.2.1 Industry dissemination

The purpose of this data collection was to identify CII products which had been accessed more frequently by industry practitioners. The data sources for industry dissemination were CII product sales and electronic download records. These numbers represent the number of copies, either in hardcopy or electronic copy format, of a specific research product that have been purchased or downloaded by CII members.

Each CII research team produces at least a research summary and a research report, and, if applicable, an implementation resource, as deliverables at the end of the research process. Those products are published in a downloadable PDF electronic copy format on the CII website and a shippable hard copy format. These publications are available for purchase at member and non-member prices (electronic copies are free for member companies). There had been only hardcopy sales until CII started publishing products online in 2001. Since 2001, both hard-copy sales and e-copy downloading have been available for users. Figure 5-3 shows the trend of CII product dissemination data from 1989 through 2010 obtained from the CII database. Since its online publishing in 2001, product dissemination has been mostly through electronic copy downloads. Therefore, both hard-copy sales and e-copy download records were collected to properly assess dissemination of individual research products.

Note that there exists a limitation using this approach in assessing dissemination of research outcomes. Since research products are available in an e-copy format, it is extremely difficult to track dissemination within the company, for example, distributing e-copies of a certain product to each project site. Therefore, this approach to assess dissemination of research outcomes may only indicate the degree of dissemination by the first distributer within an organization (e.g., CII Implementation Champion), and does not fully capture the degree of dissemination to the actual user level.

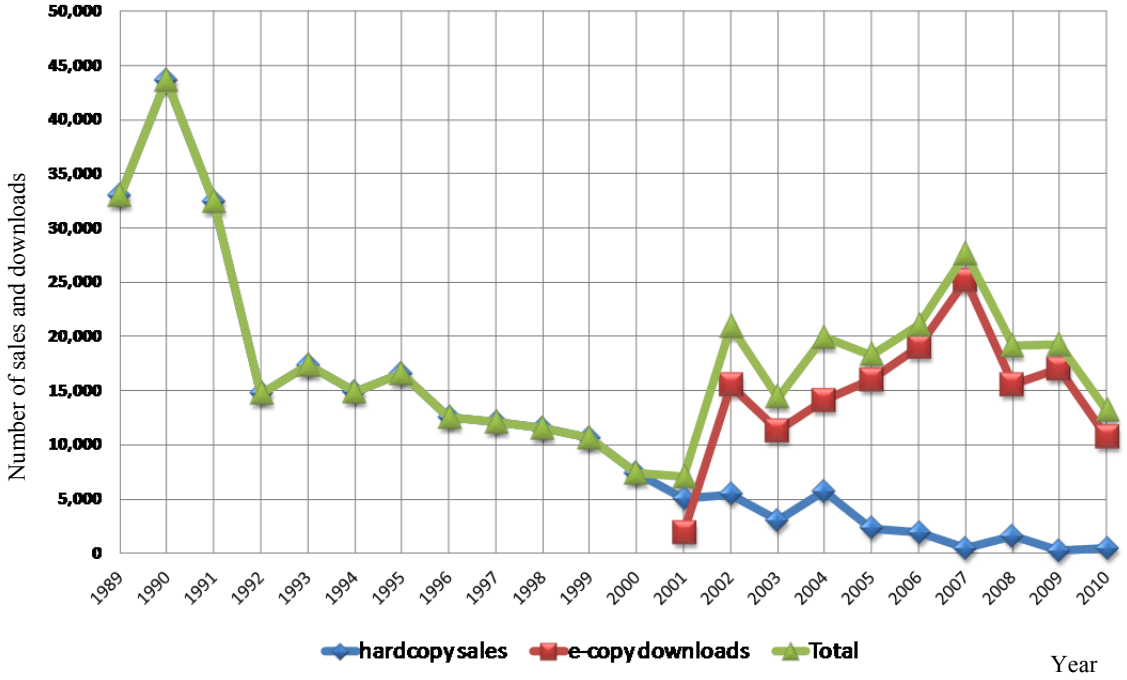


Figure 5-3: CII Product Dissemination Trend

The raw data acquired from the CII database were processed through the following steps.

1. Exclude product dissemination data of research teams started after 2006 (recent research efforts).
2. Exclude e-copy download data by CII staff members.
3. Aggregate hardcopy sales and e-copy downloads data
4. Normalize data based on lifespan of each product (number of years a product had been available).
5. Sort normalized data by CII Knowledge Structure Focus Area.

After completing the above steps on each of 456 research products of 134 research teams, 68 CII Focus Areas were rank-ordered by the number of product sales and downloads, and Table 5-3 lists the top 10 Focus Areas among others.

Rank	CII Focus Area No.	Focus Area Name
1	1.01	Front End Planning
2	11.01	Zero Accidents Techniques
3	9.01	Cost & Schedule Control
4	8.05	Benchmarking and Metrics
5	2.02	Design Effectiveness
6	2.01	Constructability
7	6.04	Craft Productivity Practices
8	8.09	Change Management
9	10.02	Project Delivery and Contract Strategies
10	8.01	Quality Management

Table 5-3: Top 10 CII Focus Areas by Product Sales and Downloads

5.2.2.2 Academic dissemination

Academic dissemination data here refers to journal citation counts of individual CII research products delivered by CII research teams. These citation counts represent how many times a specific CII research effort has been cited in academic journal articles by academic researchers. The subject journal articles investigated were those published from 1989 to 2010 and those directly citing CII products (e.g. research summary, implementation resource, or research report). Journal articles that cited other journal articles published based on CII research efforts by corresponding principal investigators were excluded since only 65 out of 134 CII research efforts that started in 1984 through 2007 have been published in academic journals.

In regard to selecting academic databases to search for journal articles citing CII products, it was considered unpractical to browse every available database. Therefore, this study used only several databases which are known as representative academic databases including Web of Science, EBSCO, Emerald, and Science Direct. Using search engines of these databases, any articles including 'CII' or 'Construction Industry Institute' in 'all text' field were searched. References of every article in search results were crosschecked to further screen out articles that did not list CII products in their references. For example, some journal articles contained 'Construction Industry Institute' in main text merely referring to the organization not referring a specific product.

As a result, a total of 424 journal articles from 75 journals were identified as citing CII research products, and these articles were put into a spreadsheet format database with data fields such as journal title, publication year, citing CII product number and title, and corresponding research team name. The next step was to filter articles by journal title. This step was conducted to limit the sources of articles to the journals listed in the Science Citation Index (SCI) journal list produced by Thomson Reuters. The first rationale of this filtering step was that previous studies indicated that research articles published and cited in high impact journals are viewed as having high quality research outputs and SCI journals are regarded as the high impact journals (Andras, 2011; Charlton & Andras, 2007; Colman et al, 1995; Wong & Gray, 2009). Second, it was decided to provide a uniform basis (i.e., same pool of journals) for comparison of citation counts and determination of rankings of the practices.

As a result of this step, 27 journals of the 75 journals were SCI journals, and a total of 255 articles from these 27 journals were finally identified. The citations of those 255 articles were sorted by research team to determine the number of citing articles of

each research team. Table 5-4 shows the top 10 CII Focus Areas that were cited most in SCI journals.

Rank	CII Focus Area No.	Focus Area Name
1	2.01	Constructability
2	7.02	Partnering
3	9.01	Cost & Schedule Control
4	11.01	Zero Accidents Techniques
5	10.01	Disputes Prevention & Resolution
6	12.04	Information Integration
7	8.09	Change Management
8	1.01	Front End Planning
9	10.02	Project Delivery and Contract Strategies
10	13.02	Global Construction Industry

Table 5-4: Top 10 CII Focus Areas Cited in SCI Journals

5.2.3 Survey assessment

A survey approach was selected to understand the degree of implementability and value as well as dissemination of CII Knowledge Structure Focus Areas as perceived by individual industry practitioners and academic researchers. Figure 5-4 presents the survey development and assessment process. It was determined to perform two types of survey with different target respondents, industry practitioners and academic researchers.

After developing initial survey questionnaires for industry and academia, a pilot survey was conducted by the Advisory Team, and the questionnaires were revised to incorporate feedback of the Advisory Team. To facilitate the survey distribution and collection process, both survey questionnaires were developed in both a Microsoft word format and a web version. SelectSurvey, which is a web survey application officially

used by CII, was used to develop web versions of the surveys to ensure security of survey data.

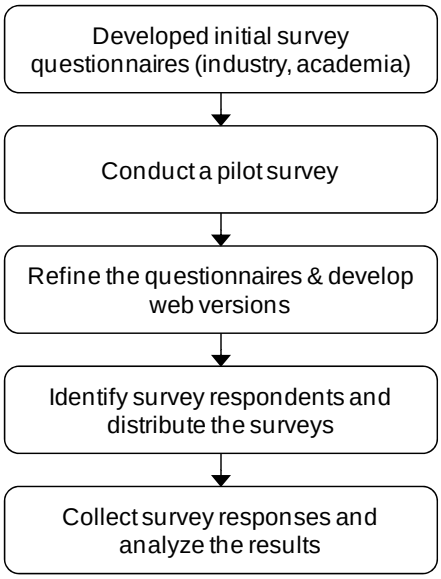


Figure 5-4: Survey Development and Assessment Process

The next step was to identify survey respondents. For both surveys, it was required for survey respondents to possess a certain level of knowledge and exposure to CII Focus Areas. Therefore, target respondents for the Industry Survey were identified from the CII Research Committee, Knowledge Management Committee, Implementation Strategy Committee, CII Board of Advisors, and CII Implementation Champions. In addition to these groups, the CII research director identified a number of individuals who have experience and knowledge with CII research. The target respondents for the Academic Survey were selected from academic researchers who had participated on at least one CII research team and/or served on any CII standing committee.

Table 5-5 summarizes overall survey responses of the Industry Assessment Surveys and the Academic Assessment Survey. The surveys were distributed to total 224 industry practitioners and 55 academic researchers from August through October 2011 with two follow-up emails.

Survey Type	Respondent Category	Survey Sent	Usable Responses	Response Rate
Industry Survey	Individual practitioners	224	53	24%
	(companies)	(111)	(47)	(42%)
Academic Survey	Individual researchers	55	31	56%
	(institutions)	(30)	(21)	(70%)
Total respondents		279	84	30%

Table 5-5: Survey Response Summary

For the Industry Assessment Survey, 224 industry practitioners were selected from 111 companies, of which owner companies were 54 and contractor companies were 57. A total of 53 usable responses were received from 47 companies with a response rate of 24%. Usable response here refers to effective responses where responses with missing data from any of survey questions were excluded. Of 53 responses, 24 responses were received from owner companies and 29 responses were from contractor companies. There were multiple responses from 5 companies. A couple of responses were received from each of 4 companies and 3 responses were received from 1 company. For the other responses, a single response was received from 1 company. The Academic Assessment Survey was sent to 55 academics from 30 universities, and a total of 31 usable responses were received from 21 universities with a response rate of 70%.

5.2.3.1 Industry survey analysis

The Industry Assessment Survey (see Appendix D) asked respondents their perception of familiarity, implementability, and value of individual CII Knowledge Structure Focus Areas. The survey first asked respondents to indicate from 59 Focus Areas, those which they had some level of knowledge (Familiarity). Next, the respondents were asked to rate the implementability, which refers to the level of implementation success of the Focus Areas, that they had checked as familiar in the previous 'Familiarity' question. The respondents were then asked to rate the value of the Focus Areas, which they had checked as familiar. Table 5-6 shows the 5-point scale that was provided to the respondents for the survey.

Question Criteria	**Rating**					
I. Familiarity	Indicate familiar focus areas (no rating)					
Rating scale	***1***	***2***	***3***	***4***	***5***	***NA/UKN***
II. Implementability	Not Successful	Somewhat Successful	Moderately Successful	Successful	Very Successful	NA/UKN
III. Value	Very Low	Low	Moderate	High	Very High	NA/UKN

* NA/UKN: Not Applicable/Unknown

Table 5-6: Industry Survey – 5-point scale rating

The top 10 Focus Areas based on the analysis of the 53 responses of the Industry Assessment Survey are listed in Table 5-7. An average of 17 respondents checked each Focus Area as 'familiar' with a standard deviation of 11.3. The highest number is 47 and the lowest number is 4 in terms of familiarity. In Table 5-7, this number of the respondents who checked as 'familiar' with a given Focus Area is shown in column (1), Familiarity Frequency.

Focus Area No.	Focus Area Name	Familiarity Frequency	Fam. Frequency %	Fam. Score	Implementability Average Score	Value Average Score	Average Score	Rank
		(1)	(2)	(3)	(4)	(5)	(6)	(7)
		number of responses	(1) / total responses	(2) ×5			Average of (3)~(5)	Ranking of (6)
1.01	Front End Planning	47	88.68%	4.43	3.80	4.52	4.25	1
11.01	Zero Accidents Techniques	34	64.15%	3.21	4.13	4.61	3.98	2
2.01	Constructability	43	81.13%	4.06	3.61	4.23	3.96	3
8.09	Change Management	32	60.38%	3.02	4.07	4.39	3.82	4
9.01	Cost & Schedule Control	32	60.38%	3.02	4.00	4.42	3.81	5
5.01	Planning for Start-up	34	64.15%	3.21	3.82	4.30	3.78	6
1.04	Construction Input in Front End Planning	37	69.81%	3.49	3.56	4.09	3.71	7
1.02	Alignment	37	69.81%	3.49	3.35	4.17	3.67	8
7.01	Team Building	32	60.38%	3.02	3.61	4.00	3.54	9
8.03	Lessons Learned	31	58.49%	2.92	3.28	4.18	3.46	10

Table 5-7: Analysis of Industry Assessment Survey – Top 10 Focus Areas

Familiarity Frequency Percentage in column (2) indicates the number of respondents who checked 'familiar' for each Focus Area divided by the total number of respondents, which is 53. This percentage refers to the degree of familiarity (or dissemination) of a given Focus Area among the survey respondents. The Familiarity Frequency Percentage (column (2)) was then converted into the 5-point scale score in column (3), Familiarly Score. Columns (4) and (5) are the average scores of implementability and value rated by the respondents who checked a given Focus Area as 'familiar', respectively. The Average Score in column (6) represents an average score of Familiarity Score, Implementability Score, and Value Score (mean of (3)+(4)+(5)). Each Focus Area was then rank-ordered by its Average Score in column (7) from largest to smallest. Those Focus Areas with higher scores were regarded as Focus Areas that were well known and disseminated, achieved implementation success, and were perceived as of value to a company or to the industry.

5.2.3.2 Academic survey analysis

The Academic Assessment Survey (see Appendix E) consisted of two sections. The first section asked the respondents to indicate those CII Focus Areas with which they were familiar and to assess the value of those familiar Focus Areas based on a 5-point rating scale (see Table 5-8). The Academic Assessment Survey did not include the Implementability question since it was assumed that academic researchers had limited knowledge of the industry implementation of the CII Focus Areas.

Question Criteria	Rating					
I. Familiarity	Indicate familiar focus areas (no rating)					
Rating scale	***1***	***2***	***3***	***4***	***5***	***NA/UKN***
II. Value	Very Low	Low	Moderate	High	Very High	NA/UKN

* NA/UKN: Not Applicable/Unknown

Table 5-8: Academic Survey– 5-point scale rating

Table 5-9 lists the top 10 Focus Areas identified from the analysis of the Academic Assessment Survey. The data were analyzed in the same manner with the industry survey analysis. Familiarity Frequency in column (1) indicates the number of the survey respondents who checked as familiar with a given Focus Area. Column (2) Familiarity Frequency Percentage is Familiarity Frequency (column (1)) divided by the total number of the survey respondents, which is 31. Column (2) Familiarity Frequency Percentages were converted into 5-point scale scores (column (3) Familiarity Score in Table 5-9). Column (5) Average Score represents the mean of Familiarity Score and Value Average Score (column (3)).

Focus Area No.	Focus Area Name	Familiarity Frequency	Fam. Frequency Percentage	Fam. Score	Value Average Score	Average Score	Rank
		(1)	(2)	(3)	(4)	(5)	(6)
		number of responses	(1) / total responses	(2) ×5		Average of (3) & (4)	Ranking of (5)
1.01	Front End Planning	27	87.10%	4.35	4.36	4.36	1
2.01	Constructability	22	70.97%	3.55	3.95	3.75	2
4.02	Lean Construction	21	67.74%	3.39	3.81	3.60	3
11.01	Zero Accidents Techniques	16	51.61%	2.58	4.50	3.54	4
7.02	Partnering	18	58.06%	2.90	3.94	3.42	5
3.01	Materials Management	19	61.29%	3.06	3.75	3.41	6
8.09	Change Management	17	54.84%	2.74	4.06	3.40	7
5.01	Planning for Start-up	16	51.61%	2.58	4.13	3.35	8
1.02	Alignment	18	58.06%	2.90	3.80	3.35	9
7.01	Team Building	17	54.84%	2.74	3.81	3.28	10

Table 5-9: Analysis of Academic Assessment Survey – Top 10 Focus Areas

5.2.4 Identification of candidate cases from old research efforts

The previous subsections presented the data collection and analysis approach to assess old CII research efforts. Since the data were collected from 4 sources (2 surveys and 2 types of product dissemination data), it was necessary to consolidate each data analysis to seek common research efforts. Figure 5-5 depicts the steps to consolidate the analyses and a set of key considerations for selecting final cases.

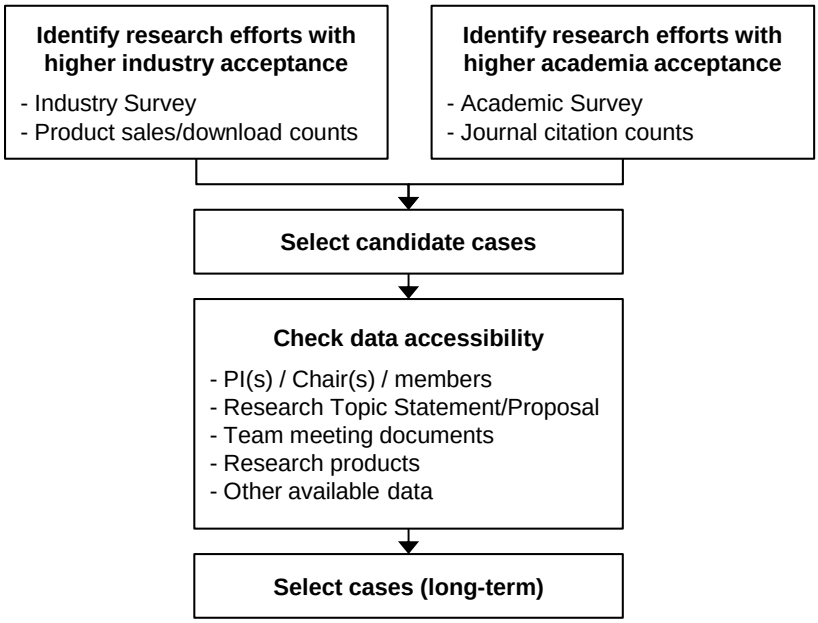


Figure 5-5: Decision Making Process for Case Identification – Established Research Efforts

Table 5-3 and Table 5-7 identified the top 10 Focus Areas identified from the products dissemination data and the Industry Assessment Survey, respectively. The common 5 Focus Areas found in both tables are listed in Table 5-10. Since this phase purports to identify research efforts to select the cases for Focused Case Studies, it was necessary to determine successful research efforts associated with the Focus Areas listed

in Table 5-10. Considering the fact that multiple research efforts are connected with a CII Focus Area, the product sales and download count data were again used to screen research efforts more successful than others by looking at those data for each product to pinpoint which product (of a team) had been more distributed within a given Focus Area.

Focus Area No.	Focus Area Name
1.01	Front End Planning
2.01	Constructability
8.09	Change Management
9.01	Cost & Schedule Control
11.01	Zero Accidents Techniques

Table 5-10: Common Focus Areas – Industry

The same approach was used for identification of cases for the academic acceptance data. Table 5-11 lists 5 Focus Areas that were common in both journal citation counts and the Academic Assessment Survey (Table 5-4 and Table 5-9, respectively). To pinpoint research efforts with more successful results for each Focus Area, the academic journal citation count data were used again as product sales and download count data were used for industry acceptance above.

Focus Area No.	Focus Area Name
1.01	Front End Planning
2.01	Constructability
7.02	Partnering
8.09	Change Management
11.01	Zero Accidents Techniques

Table 5-11: Common Focus Areas – Academic

Next, the top 10 research efforts of industry acceptance and the top 10 research efforts of academic acceptance were consolidated, resulting in 11 research efforts for the long-term assessment. These 11 old research efforts were considered as candidates for Focused Case Studies, and they were again examined against their data availability. The most important consideration was whether either academics or industry members of a research team could be contacted for interviews. Since individual interviews were deemed essential for data collection for Focused Case Studies, it was critical to select cases of which at least one academic or industry member could be reached for the interview. Another consideration was whether it was highly disseminated in both industry and academia. After this filtering process, 3 research efforts were selected as final cases.

5.3 CASE IDENTIFICATION FROM RECENT RESEARCH EFFORTS

Figure 5-6 illustrates the process for case identification and selection from recent CII research efforts. The purpose of the second data collection process was to identify cases from CII research efforts that reported out from 2009 to 2011. Consequently, their research products have not been available to the CII member companies or to the academic community long enough to assess the implementability and value of the research outcomes.

The data collection methods for the recent research efforts were CII archival records and expert group judgment. The data sources for archival records included CII product sales, Post-Research Team Surveys, and Annual Conference Evaluation Surveys for these research efforts. For the expert group judgment, a case nomination form was developed and distributed to the Advisory Team and Research Committee seeking their input on the performance of the recent research efforts.

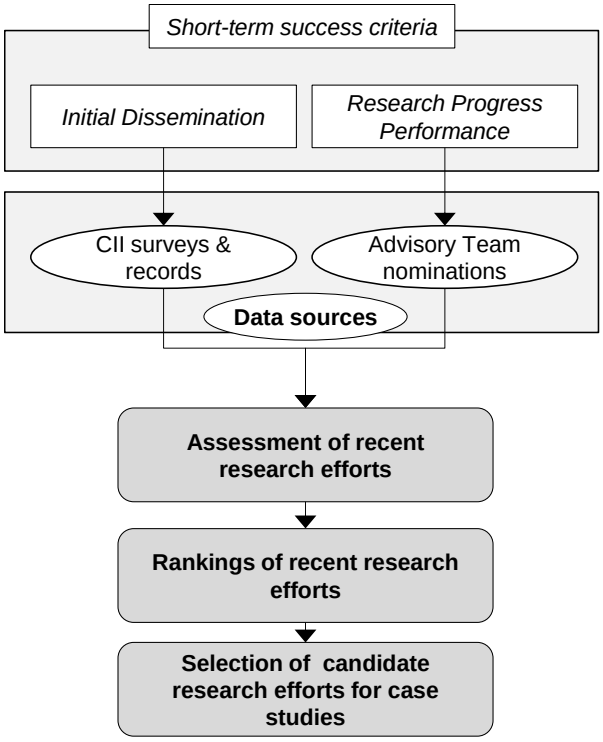


Figure 5-6: Case Selection Process for Recent Research Efforts

5.3.1 Data collection

The subjects of the data collection were 17 CII research efforts that reported out from 2009 to 2011. Multiple data sources were used to determine the short-term research success. The aggregated analysis based on these multiple data sources was expected to provide reasonably accurate assessments compared to analysis depending on a single data source.

To assess initial dissemination of individual research products, CII product sales and download data were first collected and converted to normalized numbers. Second, the Post-Research Team Surveys of the 17 research efforts were analyzed and an average rating score for each team was generated. The Annual Conference Survey ratings were also analyzed and the average rating score for each team was calculated.

A case nomination form (see Appendix E) was developed to assess expert evaluation on the recent research efforts and was distributed to the members of the Advisory Team and the Research Committee. The nomination form asked the respondents to assess their top 5 CII research efforts that they considered as successful research as well as the top 5 choices for less than successful research in rank order. The form also asked the respondents to provide the main reasons for their assessments. The nomination form was distributed to 16 members of the Research Committee including the Advisory Team, however only five members were able to provide responses.

5.3.2 Data analysis

Table 5-12 shows the data analysis for the recent research efforts. The rank of each research team was determined by summing the ranks of 4 data analyses, which were nominations from the Advisory Team and the CII Research Committee (RC), research product sales/download numbers, Post-RT Survey responses, and Annual Conference Survey ratings. In Table 5-12, column (2) is the sum of columns (3) through (7). The column (4), the rankings of 'Less than successful' is the reversed rankings (i.e., ranking 1 is the least nominated research team as less than successful by RC) to ease calculation of total rankings. Since the Annual Conference Survey is conducted annually for research teams that report out a given year, Column (7), rankings of the Annual Conference Survey ratings indicate the rankings of the research teams reported out in a same year. Therefore, the rankings in Column (7) represent the rankings of the research efforts within a same year group. Column (1) is the rank-order of the research team by column (2). For confidentiality reasons, research team names were coded.

Rankings	Research Team	Sum of individual ranks	Rankings of RC Nominations		Rankings of product sales/ downloads	Rankings of Post-RT Survey	Rankings of Annual Conference Survey rating
			Successful	Less than successful			
(1)		(2)	(3)	(4)	(5)	(6)	(7)
Rankings of (2)		∑ [(3)~(7)]		Reversed rankings			Rankings of a given year
1	**a**	16	7	1	5	1	2
2	**b**	17	12	1	1	N/A	3
3	**c**	21	3	1	2	11	4
4	**d**	24	2	1	11	5	5
5	**e**	29	12	8	4	2	3
6	**f**	29	1	1	14	7	6
7	**g**	29	12	1	9	6	1
8	**h**	30	5	1	12	10	2
9	**i**	36	8	15	3	8	2
10	**j**	39	9	8	7	14	1
11	**k**	41	4	15	16	3	3
12	**l**	42	6	14	8	13	1
13	**m**	45	12	8	10	9	6
14	**n**	45	10	8	15	4	8
15	**o**	54	12	8	13	16	5
16	**p**	54	11	17	6	15	5
17	**q**	56	12	8	17	12	7

Table 5-12: Aggregated Analysis for Recent Research Efforts

5.4 CASE CATEGORIES

A total of 11 cases were selected as final cases for Focused Case Studies based on 4 categories. These 4 case categories and the descriptions are shown in Table 5-13.

Research timeframe	Case Category	Description	Case ID
Completed in 1988~2008	*Established*	Established research efforts that have been acknowledged as successful by both industry and academic users	E1 E2 E3
Completed in 2009~2011	*Distinguished*	Recent research efforts evaluated as having produced quality outcomes	D1 D2 D3
	Atypical	Recent research efforts evaluated as having experienced atypical challenges that had hindered from completing research with desirable outcomes	A1 A2 A3
	Special	Recent research efforts with mixed assessment on research outcomes	S1 S2
			Total 11 cases

Table 5-13: Case Categories and Descriptions

These categories were established to select "extreme cases" (Patton, 2001) for case studies to compare the findings from very different cases. In this study, 'Distinguished' and 'Atypical' are extreme cases, and 'Established' and 'Atypical' are extreme cases as well. The category 'Special' here was added later in the course of data analysis to investigate the research efforts which turned out to have contradictory assessment on performance or unique research aspects. All of the 'Established', 'Distinguished', and 'Special' cases are considered more successful than the 'Atypical' cases. However, the 'Established' cases were evaluated as successful in long-term

whereas the ‘Distinguished’ and ‘Special’ cases were evaluated as successful in short-term. In other words, the success of the ‘Established’ cases has been established over a long period of time while the success of the ‘Distinguished’ and ‘Special’ cases needs further validation and confirmation from a long-term perspective. For confidentiality purposes, each research effort was given a code, as presented as Case ID in Table 5-13, that was unassociated with any information of a given research effort.

5.5 SUMMARY

This chapter described the third phase of this study, identification and selection of cases for Focused Case Studies. A unique approach, dual data collection and analysis process was formulated to properly collect and analyze data to indicate research efforts and to best support the case studies. Data were collected from multiple sources using multiple methods, which provided strength to the analysis results. A total of 11 research efforts were finally selected from 152 CII research efforts. These 11 cases were representative CII research efforts characterized by ‘Established’, ‘Distinguished’, ‘Atypical’, and ‘Special’. The top 3 old research efforts identified as proven successful over a long period of time were grouped as ‘Established’, and top 3 recent research efforts identified as having delivered quality products were categorized into ‘Distinguished’. The 3 recent research efforts that were assessed as not having produced desirable outcomes due to unusual challenges were characterized as ‘Atypical’. A coule of recent research efforts with unique assessments were grouped into the ‘Special’ case category. The next chapter will discuss the case study process of these 11 cases.

Chapter 6: Focused Case Studies

This chapter presents a multiple case study process including the descriptions of data collected and case analysis approaches, followed by a discussion of individual case analysis.

6.1 Overview

The purpose of this phase was to investigate the research processes of the 11 cases selected from the previous phase focusing on research methodology, team dynamics, and product development in an attempt to identify research process attributes that had impacts on research outcomes. The primary data collection method used was in-depth interviews with selected individual participants of the 11 cases. Documents and archival records were also collected and analyzed to supplement the interviews data. Based on the data collected, an individual case report was developed for each of the 11 cases in preparation for the cross-case analysis in the next phase.

6.2 Case Study Design and Data Analysis Approach

The case study approach selected for this study was a multiple-case study, particularly investigating extreme cases for a comparative study (Patton, 2002; Yin, 2009). This approach was selected to identify key research process attributes by comparing data collected from two extreme types of cases; one with more successful outcomes and the other with less successful outcomes. The unit of analysis of the case study was the research process of individual CII research efforts. The unit of analysis was defined based on the research objectives and questions (Yin, 2009). The subunits of analysis included research methodology, team dynamics, and product design and

development. The data were collected from the 11 cases and analyzed across cases focusing on these subunits and unit of analysis.

Yin (2009) suggested 4 general strategies in analyzing case study data. First, the data are collected and analyzed based on the research propositions. Second, an individual case description is developed for each case. Third, both qualitative and quantitative data are collected and analyzed. Fourth, rival explanations of a hypothesis are considered and examined. This study adopted these four general strategies in data collection and analysis. The main analysis technique used in this study was a cross-case analysis where all the data from the individual cases were synthesized and any apparent patterns and/or themes were investigated across cases (Yin, 2009). The cross-case analysis of this study will be further described in the next chapter.

6.3 CASE STUDY PROCESS

Figure 6-1 illustrates the process of Focused Case Studies. First, the case study plan was developed as a master plan which defined sources and collection methods for all types of data of the 11 cases to ensure both qualitative and quantitative data being collected. This plan also included milestones for major data collection activities and interview schedules.

Once the plan was developed, the data collection effort started with developing a case study interview guide and questionnaires. The interview guide was developed to assist the interviewer in maintaining focus during the course of interviews (Patton, 2002). The interview guide outlined the major interview question areas that were derived from the research propositions. This interview guide was sent via email to interview participants prior to the interview for their information and preparation. The interview guide is provided in Appendix F.

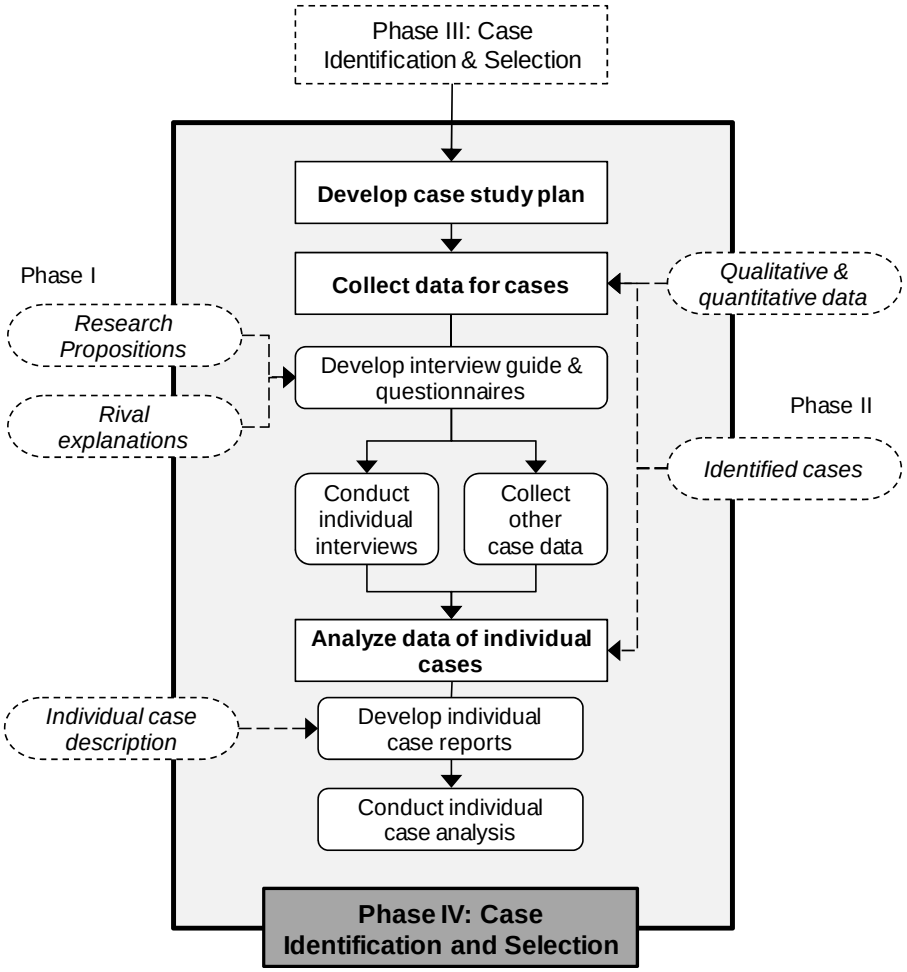


Figure 6-1: Process of Focused Case Studies

While the interview guide outlined the interview topics at the upper level, the interview questionnaires for academic and industry interviewees were prepared listing the detailed actual questions that the interviewer would ask to the interviewees. The interview questions were formulated to obtain multiple perspectives and perceptions of the interviewees as well as to examine the research propositions and the rival explanations. Along with conducting interviews with the selected individuals, various documents and records of each case were collected to supplement the interview data. For

instance, team rosters, meeting minutes and meeting rosters were obtained to validate and complement the interview response to the question "How were team attrition and meeting attendance?"

The third step of the process was to analyze data collected for each case. The individual case reports were prepared in accordance with the third general strategy of data analysis suggested by Yin (2009). Although Yin recommended this approach as an alternative when it is difficult to rely on data analysis around theoretical propositions, this study employed the approach for the following reasons. First, the individual case reports were developed to synthesize, reduce, and organize data of each case that were relevant to the context of this study. Second, while developing the individual case reports, there was a desire to immerse the researcher into data so that the researcher could understand the context of each case. Finally, as Yin (2009) noted, this approach helped identify appropriate relationships among the data and prevented reaching a hasty conclusion. In addition, it helped the researcher discover rival explanations through insight of individual cases.

6.4 DATA COLLECTION

6.4.1 Data sources for the case studies

Table 6-1 shows data collection methods and sources for this phase. The main data source was the individual interviews. Besides the interviews, various documents and archival records were collected to triangulate data as well as to obtain both qualitative and quantitative data.

Phase IV. Focused Case Studies	
Data Collection Methods	**Data Sources**
Individual interviews	Selected industry/academic team members
Documents	- research proposal - team charter - research products (research summary /research report/implementation resource) - team meeting minutes
Archival records	- Post-Research Team Survey - Annual Conference Survey - CII product sales/download data - Team meeting attendance records

Table 6-1: Data Collection Methods and Data Sources – Focused Case Studies

6.4.2 Structure of the interview questions

Table 6-2 presents the interview question structure. The interview questions were developed based on 3 levels of category. The first level category represents the 3 subunits of analysis, which are research methodology, team dynamics and management, and product design and development. In addition, question areas such as overall, lessons learned, research outcomes, collaborative academia-industry research, and recommendations, were added to the first level. The category level 2 indicates the research propositions, and the category level 3 includes the detailed question subjects associated with each of level 2 categories. Once a standard questionnaire was developed based on this structure, 3 different versions were developed with slight changes suited for academics and industry members (see Appendix G and Appendix H). The total number of questions of a standard questionnaire was 72 including sub-questions.

Category Level 1 (Case Subunits)	**Category Level 2** (Proposition Level)	**Category Level 3** (detailed questions from Category Level 2)
I. Overall Questions	A. Strengths and weaknesses	
	B. Research phases	
II. Research Methodology	A. Scoping	Research topic statement/essential question/proposal/scope/vision /deliverables/milestones
II. Research Methodology	B. Data collection, analysis and validation	methods and processes, industry members' roles
III. Team dynamics	A. Team organization	subgroups, team composition, diversity
	B. Team participation	team attrition and meeting attendance, member commitment and engagement, factors to industry participation, PI/chairs roles
	C. Leadership	leadership orientation, roles and responsibilities, core group, leader skill sets
	D. Alignment process	overall alignment process, personal conflicts
	E. Academia-industry collaboration	benefits, factors to productive collaboration, relationships among team members
	F. Communications and meetings	communication methods, meeting management, social activities, graduate student
IV. Product design	A. Product quality	overall quality of the deliverables, implementability and value, usability, feedback from industry users
	B. Product development	roles and responsibilities of industry members, key considerations, tool development, innovative ideas

Table 6-2: Interview Question Structure

Category Level 1 (Case Subunits)	**Category Level 2** (Proposition Level)	**Category Level 3** (detailed questions from Category Level 2)
V. Lessons Learned		lessons learned, similarities & differences with previous/later teams
VI. Research Outcomes		contributions of the research, personal benefits
VII. Academia-industry collaborative research	A. Definition of research success	success criteria, qualities of a successful research project, key success factors, academic rigor and industry practical relevance
VIII. Recommendations		

Table 6-2, continued.

6.4.3 Individual interviews

To identify candidate interviewees, team rosters and meeting minutes were closely reviewed against the interviewee selection criteria presented below.

1) Roles and responsibilities – PIs, chairs, team members
2) Meeting attendance – 50% or more
3) Company membership category – owner and contractor balance
4) Accessibility – time availability, location
5) CII research team experience – multiple vs. single team experience

A total of 76 individuals, 21 academics and 55 industry practitioners, were finally selected considering the criteria above. Of these 76 candidate interviewees who were contacted, 17 academics and 23 industry practitioners were interviewed. Table 6-3 presents the number of interviewees of each case.

Case Category	Case No.	Academics	Industry		Total	*Previous CII research experience*	
		Principal Investigator	**Co-Chair**	**Member**		***Academics***	***Industry***
Distinguished	D1	1	1	1	3	0	Co-chair & 1 member
	D2	1	1	2	4	1	Co-chair
	D3	2	1	3	6	Co-PI	0
Atypical	A1	1		1	2	0	0
	A2	1	1	2	4	0	member
	A3	2		2	4	Both PIs	1 member
Established	E1	2			2	0	
	E2	1		1	2	1	0
	E3	1			1	1	
Special	S1	2		2	4	Co-PI	0
	S2	3	1	3	7	All PIs	Co-chair
	Total	**17**	**5**	**17**	**39**		

Table 6-3: Interviewee Summary

Of the 22 industry interviewees, 8 were from owner companies and 14 were from contractor companies. Of the 5 co-chair interviewees, 3 were from owner companies and 2 were from contractor companies. At least one academic and one industry member were interviewed for each case to understand both perspectives to the research process as well as to maintain a balanced view from multiple interviewees. Nevertheless, due to the difficulty of tracking contact information of industry members of Established cases, industry members could not be interviewed for the cases E1 and E3.

The primary interview method was in-person interviews with supplement of phone interviews and web video interviews. A total of 39 interviews were conducted, of which 30 interviews were conducted in-person, 7 interviews were conducted through web video call applications, and 2 interviews were conducted via phone. The interview durations ranged from 0.6 hours to 2.5 hours with an average of 1.7 hours and a median of 1.7 hours depending on time availability of individual interviewees. A pilot interview was conducted with an academic who was familiar with the CII research process to seek feedback and input. After this pilot interview, the interview questions were refined to more effectively and clearly deliver the questions to the interviewees.

At the beginning of each interview, the Informed Consent and Confidentiality (see Appendix I) form was provided to every interviewee. This form detailed the purpose of this study, a brief overview of the interview questions, and the interviewee's rights as a study participant. At the end of the form, the interviewee had option to agree or disagree to be audio-recorded. This form also collected the signature of the interviewee and interviewer with the date of the interview recorded.

6.4.4 Other case data

Other documents and records related to each case were collected in addition to the interviews. Not every datum was available for every team. For instance, team meeting minutes of old cases were not available for collection. Data availability of the 11 cases is summarized in Appendix J.

6.5 INDIVIDUAL CASE ANALYSIS

6.5.1 Overview of individual cases

Table 6-4 provides a general summary of information for the 11 cases. This table provides an objective background of each case in terms of project period, team attrition, chair and PI information including changes and previous CII research experience, and the number of products published on the CII website. This table also provides a quick comparison of background information across cases.

The preliminary finding from this table was that there was no apparent pattern distinguishing one case category from another. For example, every case of the Distinguished, Atypical, and Special categories experienced at least one chair change, chairs with no previous CII research experience, and PIs with no previous CII research experience. Distinguished cases seemed to have a slightly higher average number of attendees per meeting than Atypical and Special cases, but not by a significant margin.

Case Category		Distinguished			Atypical			Established			Special	
Case ID		D1	D2	D3	A1	A2	A3	E1	E2	E3	S1	S2
Project Period	calendar year	2 years	3 years	2 years	3 years	2 years	2 years	4 years	3 years	3 years	2 years	6 years
	extension		1 year		1 year							
Chair(s)	number	2	2	2	2	2	2	1	1	1	2	2
	chair change	Yes	Yes	No	Yes	No	No	No	No	No	No	Yes
		one co-chair	both co-chairs		one co-chair							one co-chair
	previous CII research experience	Yes	No	No	No	Yes/No	No/Yes	No	No	No	Yes	Yes
		both co-chairs				One co-chair	One co-chair					
Principal Investigator (PI)	number	2	2	2	2	2	2	2	1	1	2	3
	PI change	No	Yes	No	Yes	No	No	No	No	No	No	No
			co-PI		Lead-PI							
	previous CII research experience	No	Yes	No/Yes	Yes/No	No/Yes	Yes	No	Yes	Yes	No/Yes	Yes
			both PIs	lead-PI: No	co-PI: No	lead-PI: No	both PIs				lead-PI: No	
Members	previous CII research experience (excl. chairs)	1	2	None	2	3	3	None	None	2	3	7
Meeting attendance (excl. PIs)		11.56 /17.56 (66%)	13.55 /26.55 (50%)	10.67 /15.67 (68%)	UK	10/19 (52%)*	10.5 /17.13 (61%)		UK	UK	UK	UK
number of Products Published	RS	1	1	1	1	1	1	2	1	2	1	4
	IR	1	1	1	0	0	0	1	2	0	1	3
	RR	1	1	1	1	1	1	4	3	2	1	3

- UK: Unknown
- *: average of 3 face-to-face meetings

Table 6-4: Case Information Summary

Of interest is the number of products published by each case. As shown in the table above, none of the Atypical cases produced an implementation resource (IR) while other cases produced at least one IR except the case E3 which produced two research summaries (RS) and two research reports (RR). It may be possible that this is a result of team performance rather than a cause of it. In other words, it may have been difficult for the Atypical cases to produce an IR because of the lower overall team performance or perception of value being created.

In summary, in regard to case general information, only 'PI change' appeared to be a critical factor that separated cases into more successful and less successful. These aspects will be discussed again in the next chapter combined with the interview data analysis to discover any emerging findings.

6.5.2 Development of individual case reports

After collecting all the relevant data, individual case reports were developed for the 11 cases. As discussed earlier, the purposes of this process were, first, to integrate and triangulate data, second, to screen and to reduce data into manageable level, third, to immerse the researcher into data of a given case, and fourth, to provide base data for cross-case analysis. To develop an individual case report, interview data, relevant documents, and archival records of a case were gathered and combined for data triangulation. These data were selected, reduced and organized into a manageable level for each report to provide a "thick" and "rich" description. These individual reports were developed with sufficient detail to be comprehensive. These reports were written as objective and descriptive narratives, with personal biases and interpretations of the researcher minimized. This process was intended to "find", "discover", and "learn" about each case for the researcher.

The individual case report in general consisted of two sections; the case introduction and the case analysis sections. The introduction section summarized case information and data collected, and the case analysis section described the case data organized and structured by the interview questions. The individual case reports are provided in Appendix M.

6.6 SUMMARY

This chapter discussed the process of Focused Case Studies. This study employed a multiple-case study design to compare data across the 11 cases to find apparent and emerging patterns. The primary data source was individual interviews, complemented by other data such as team meeting minutes and research products. A total of 39 individuals were interviewed on a one-to-one basis. As data were collected, the individual case report was developed for each case where all the data collected were synthesized into a descriptive narrative. The next two chapters will discuss comprehensive analysis across the 11 cases based on the individual case reports.

Chapter 7: Comprehensive Cross-Case Analysis (I)

This chapter and the next chapter present comprehensive cross-case analyses of the 11 cases. This chapter will discuss the cross-case analysis on three case subunits, which are research methodology, team dynamics, and product design and development, and validation of propositions. This is an attempt to answer the third research question, which is to identify process attributes and key success factors, and, consequently, to achieve the third objective of this study. The next chapter will provide discussion of the cross-case analysis on additional categories besides the three case subunits.

7.1 CROSS-CASE ANALYSIS PROCESS (I)

The analysis techniques used for the cross-case analysis were content analysis and pattern analysis. Content analysis indicates a qualitative data analysis technique to reduce data and to identify meaningful and core concepts or themes through "analyzing text" of data, such as interview transcripts and documents (Patton, 2001). Pattern analysis refers to matching the patterns related to "predicted values" across cases based on the content analysis (Yin, 2009). For example, in terms of industry leadership of a collaborative academia-industry research team, 'strong chair leadership' on more successful teams and 'weak chair leadership' on less than successful teams are the "predicted values". Pattern analysis is matching actual analysis outcomes and the "predicted values"; to examine whether more successful teams actually report strong chair leadership and less than successful teams report weak chair leadership or not in the case of the above example.

Figure 7-1 illustrates the process of the cross-case analysis on research methodology, team dynamics, and product design and development. First, the interview transcriptions and other data (meeting minutes, research products, etc.) of the 11 cases were organized into three category levels – case subunits, research propositions, and

interview questions (refer to Table 6-2). These three category levels were predetermined from the conceptual research framework and propositions. These pre-defined themes play as "substantive and theoretical categories" which are helpful in organizing and analyzing a large amount of data in qualitative research by allowing the researcher focus on relevant data to research topic or questions (Maxwell, 2004).

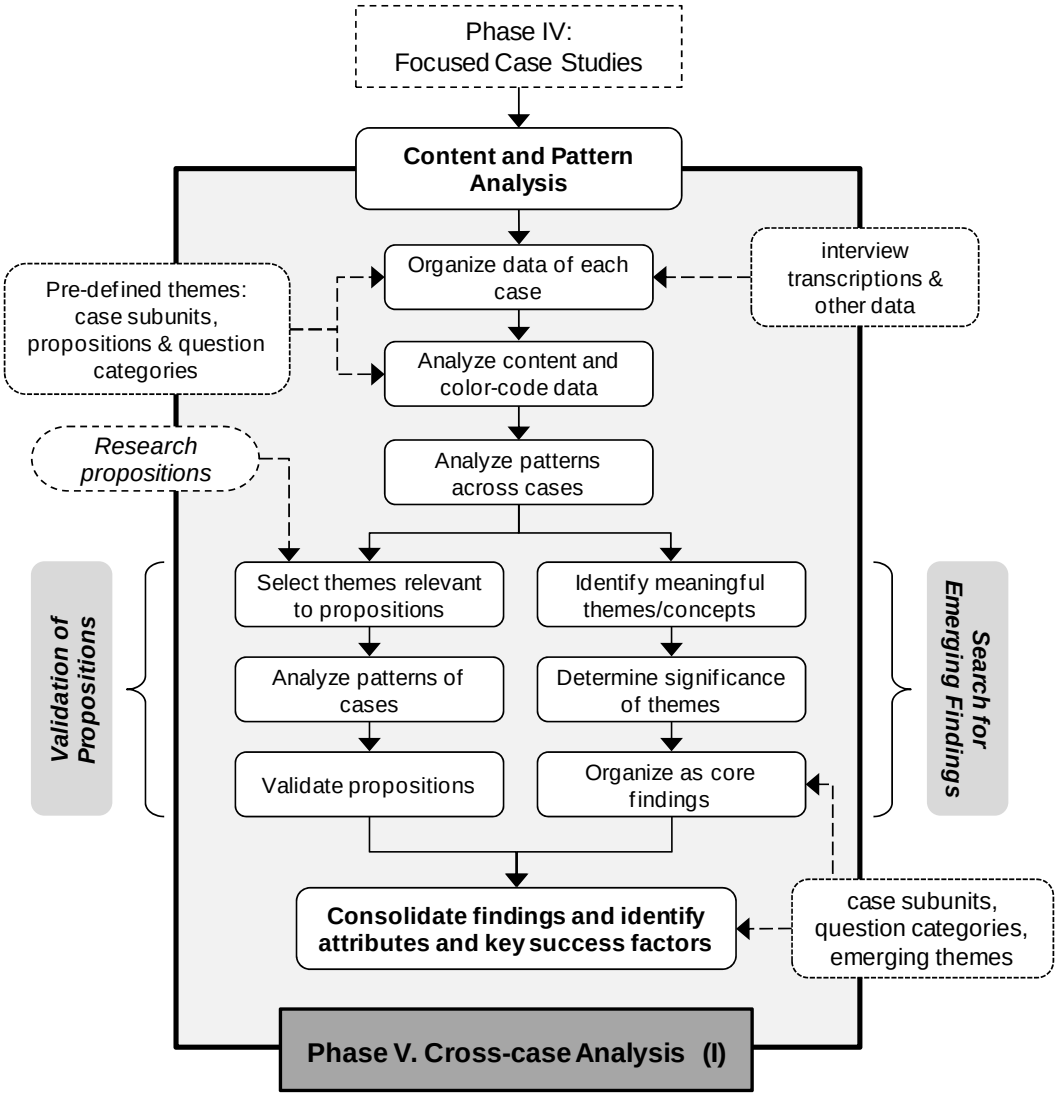


Figure 7-1: Cross-Case Analysis Process (I)

After case data were grouped into the third category level (detailed interview questions) where 52 categories were included, the content analysis was conducted and each case was color-coded for each of 52 categories. Then, the patterns of the 11 cases were analyzed by counting the occurrence of the patterns (i.e., color-coding). An example of this color-coding is provided in Appendix K.

The next step included two analysis efforts. The first effort was proposition validation, and the second effort was identification of emerging findings. This two-step analysis approach was applied to avoid discovering findings only around the pre-established framework (i.e., research propositions) and to allow exploring further meaningful themes or concepts from the case data.

First, to validate the 11 research propositions, the pre-defined 52 categories were reviewed to select categories relevant to the propositions. Then, the patterns of the 11 cases were examined for the selected categories. Next, to reveal emerging and/or unexpected concepts or themes, the content and patterns of the 11 cases were carefully reviewed category by category to find out any meaningful or recurring themes. These newly identified themes and/or concepts were then closely examined to determine their significance. This step was conducted to screen the data that are more solid, relevant, meaningful and useful for the study purposes using a researcher's judgment (Patton, 2001). After this step, the selected themes were organized in accordance with the case subunits. One thing that should be noted is that these two analysis processes were neither linear nor separate. They were closely related and complementary to confirm and support each other's findings.

The final step was consolidation of the findings from both approaches, and based on the consolidated findings, key process attributes and success factors were identified.

These key attributes and success factors will be discussed in the next chapter with the findings of the second part of the cross-case analysis.

7.2 CASE CATEGORIES AND DESCRIPTIONS

For the purposes of the cross-case analysis in this chapter, the case categories and descriptions are again provided in Table 7-1.

Case Category	Description	Case ID
Distinguished	Recent research efforts evaluated as having produced quality outcomes	D1 D2 D3
Atypical	Recent research efforts evaluated as having experienced atypical challenges that had hindered from completing research with desirable outcomes	A1 A2 A3
Established	Established research efforts that have been acknowledged as successful by both industry and academic users	E1 E2 E3
Special	Recent research efforts with mixed assessment on research outcomes	S1 S2
		Total 11 cases

Table 7-1: Case Categories and Descriptions

7.3 VALIDATION OF THE PROPOSITIONS

The data sources used for proposition validation included the interview data, Post RT Survey, research report, and product downloads and sales data of each case. The validation approach was first, to color-code each case for the interview question categories (category level 3) related to the propositions; second, to count the number of cases supporting the proposition by case category; third, to determine whether the

proposition was supported if there was a clear difference (pattern) between the Atypical cases and the other cases. The detailed pattern analysis for proposition validation is provided in Appendix L.

The 11 propositions were the "predicted values" of a hypothetical "ideal type" successful collaborative academia-industry research team. If a proposition was seen in the cases other than the Atypical cases, the proposition was concluded as supported by the case analysis (pattern matching). The validation results are summarized in Table 7-2. Eight propositions were supported, and three propositions were partially supported. Those three propositions are propositions 1, 6, and 7, which are related to the research scoping, innovativeness, and alignment, respectively.

Propositions 1, 6, and 7 were concluded as partially supported since the 11 cases did not show apparent differences between the Atypical cases and the others. The Proposition 1 is "The research scope is well defined and clearly addresses the topic and research question within the time and cost constraints of the study." To validate this proposition, the interview contents were analyzed in terms of significant alignment issues around the scope and scope changes. Of the 11 cases, 5 cases experienced alignment issues and only one of those five cases was from the Atypical cases. Only 2 cases changed the research scope, one from the Established cases and the other from the Special cases. Therefore, it was difficult to conclude that the cases with better performance had less alignment issues and less scope change. Proposition 7, "The team is well aligned around research objectives and methodology." was concluded as 'partially supported' for the same reason.

Category	Propositions	Supported?
Research Methodology		
Scoping	1. The research scope is well defined and clearly addresses the topic and research question within the time and cost constraints of the study.	partially supported
Research plan	2. The research plan, methodology, and data collection methods are well designed and thus, properly explored the topic and answered the research question.	supported
Research methodology	3. The methodology follows the "Problem/Question → Hypothesis → Data Collection/Analysis→ Validation → Implementation Guidance" model or an appropriate variation of this model.	supported
Data collection methods	4. The data collection methods are developed to adequately support the research topic and objectives.	supported
Data analysis and validation	5. Data and analyses are objective and adequate for the testing and validation of the hypothesis.	supported
Innovativeness	6. The research process encourages breakthrough thinking.	partially supported
Team Dynamics		
Alignment	7. The team is well aligned around research objectives and methodology.	partially supported
Participation and commitment	8. The team members are committed and actively participated in the research throughout the research process.	supported
Chair leadership	9. The leadership provided by the team chair(s) inspires member participation and commitment, and is integral to the team's success.	supported
Academic-industry collaboration	10. Academic and industry team members clearly understand their respective roles and responsibilities, and the research effort reflects their synergistic collaboration.	supported
Product Design and Development		
Product quality	11. The research product provides clear and practical guidance for implementation, as appropriate, and is easy to understand and ready to use.	partially supported

Table 7-2: Proposition Validation by Category

Proposition 6 is "The research process encourages breakthrough thinking." The 11 cases in general did not particularly show that they adopted approaches to encourage breakthrough thinking. It could be partially due to that it was difficult to judge whether specific approaches or processes used by cases promoted innovative thinking or not.

Proposition 11 is "The research product provides clear and practical guidance for implementation, as appropriate, and is easy to understand and ready to use." This proposition was concluded as 'partially supported'. The product quality needed to be assessed from team members as well as users. From the user standpoint, which was assessed by the numbers of product e-copy downloads and hardcopy sales, this proposition was supported for the Established cases. For the 8 recent cases, there was no significant difference in the numbers of product e-copy downloads and hardcopy sales between the Atypical cases and the other cases. However, all of the Characteristics and the Special cases produced implementation resources to provide the industry guidance to implement their research outcomes while the Atypical cases did not. Therefore, it was concluded that this proposition was partially supported.

7.4 PATTERN ANALYSIS OF EMERGING FINDINGS

After the proposition validation, the content of the 11 cases of 52 pre-defined categories were carefully reanalyzed to discover emerging themes. During this reanalysis process, the 52 categories were further divided into 102 subcategories (or themes) derived from the content analysis of the interview transcriptions and other data. With the completion of the analysis, a total of 28 themes were identified as the emerging themes of which 6 were related to research methodology, 20 were related to team dynamics, and 2 were associated with product design and development. Tables 7-3, 7-4, and 7-5 show the pattern analysis of the 11 cases for each theme in research methodology, team dynamics,

and product design and development, respectively. In the following sections, the content analysis of the 28 themes shown in Tables 7-3, 7-4, and 7-5 will be presented. The content analysis was conducted based on the individual case descriptions provided in Appendix M and the individual interview transcriptions.

	I. Research methodology	**Distinguished (3 cases)**	**Atypical (3 cases)**	**Established (3 cases)**	**Special (2 cases)**	**Sum (11 cases)**
1. Scoping						
1)	no alignment issues	1	2	2	1	**6**
2)	no scope change	3	2	2	1	**8**
2. Data collection & analysis						
3)	multiple data collection methods & sources	2	0	3	2	**7**
4)	challenges – data amount	2	2	0	1	**5**
3. Others						
5)	industry background study	2	2	2	2	**8**
6)	evolving	2	0	2	0	**4**

Table 7-3: Pattern Analysis – Research Methodology

II. Team dynamics		Distinguished (3 cases)	Atypical (3 cases)	Established (3 cases)	Special (2 cases)	Sum (11 cases)
1. Team Composition						
1)	expertise & experience	3	3	3	2	**11**
2)	diversity	0 (2-mixed)	1	1	0 (2-somewhat)	**2**
2. Participation and Commitment						
3)	less team attrition	2	0	1	1	**4**
4)	core group	3	2	2	2	**9**
5)	strong participation	3	0 (1-mixed) (1-somewhat)	1 (1-somewhat)	1 (1-mixed)	**5**
6)	participation factors					
	• leadership	3	1	2	1	**7**
	• value/benefit /vision	2	1	2	2	**7**
	• meeting effectiveness	1	1	2	2	**6**
	• interest & passion	3	1	0	1	**5**
	• learning	2	0	2	0	**4**
	• fun	2	0	1	1	**4**
	• relationship	2	0	0	2	**4**
3. Subgroup Approach						
7)	use subgroups	3	1	1	2	**7**
8)	from the start	2	0	1	0	**3**

* ‘mixed’ refers to the mixed or conflicting views of the interviewees within a case.

Table 7-4: Pattern Analysis – Team Dynamics

II. Team dynamics		Distinguished (3 cases)	Atypical (3 cases)	Established (3 cases)	Special (2 cases)	Sum (11 cases)
4. Leadership						
9)	balanced between academics and industry	2 (1-academic-led)	0 (1-industry-led) (2-mixed)	0 (3-industry-led)	1 (1-mixed)	**3**
10)	strong chairs	2	0 (1-mixed) (1-somewhat)	3	2	**7**
11)	strong PIs	3	0 (1-mixed) (1-somewhat)	1	2	**6**
12)	good alignment between PIs	2	1 (1-mixed)	1 (2-single PI)	2	**6**
13)	separate roles and responsibilities	2	0	2	2	**6**
14)	regular leadership communications	1 (1-mixed)	0	3	1	**5**
5. Team Relationship						
15)	overall good relationship	3	1 (1-mixed)	1	2	**7**
16)	no personal conflicts	1 (2-somewhat)	2 (1-had conflicts)	2 (1-had conflicts)	2	**7**
6. Team Management						
17)	meeting minutes	3	1	1	2	**7**
18)	meeting facilitation by chairs	2 (1-PIs)	1 (1-mixed) (1-PIs)	3	0 (2-PIs)	**6**
19)	social activities	3	2	0	2	**7**
20)	good GRA	1	0	2	2	**5**

Table 7-4, continued.

III. Product Design & Development		Distinguished (3 cases)	Atypical (3 cases)	Established (3 cases)	Special (2 cases)	Sum (11 cases)
1. Product Design & Development						
1)	Industry member involvement in writing	2	1	1	0 (1-mixed)	4
2)	Product quality	3	1	3	2	9

Table 7-5: Pattern Analysis – Product Design and Development

7.5 EMERGING FINDINGS – I. RESEARCH METHODOLOGY

The key findings in regard to research methodology are summarized as below (see Table 7-3). Each of these 6 findings will be discussed in detail in the subsections.

I-1. 5 cases had alignment issues. It appeared across the case categories.

I-2. Scope changes only appeared in 2 cases (one Atypical and one Established).

I-3. The Atypical cases did not use multiple data collection methods and sources.

I-4. 5 cases had difficulty in collecting a sufficient amount of data. The Established cases did not experience a challenge associated with data amount.

I-5. Industry members in 8 cases participated in background studies.

I-6. *"Evolving"* nature of the research scoping and methodology development process was mentioned in 2 Distinguished cases and 2 Established cases.

From the key findings of the pattern analysis above, the apparent difference between the Atypical cases and the other cases were; 1) use of multiple data collection

methods and sources; and 2) awareness of evolving nature of research scoping and methodology process.

7.5.1 Scoping

7.5.1.1 Scoping – alignment issues

Finding I-1. 5 cases had alignment issues. It appeared across the case categories.

As Gibbons et al. (1994) noted, Mode 2 knowledge production is heterogeneous and organizationally diverse since experts or specialists from various organizations are involved in and work collaboratively to produce applicable knowledge. In such an environment, clear establishment of the research problems and objectives, and development of a mutually agreed research plan have been addressed as key success factors in extant literature (Barneds et al., 2006; Kulatunga et al., 2010). This alignment process during the scoping phase is sometimes accompanied with debates or conflicts resulting in lengthy discussions, which may slow down a team from achieving early agreement and alignment on the research scope and objectives.

However, experiencing alignment issues during the scoping phase did not always negatively impact the research team performance for the 11 cases. All the 11 cases reported that they spent a significant amount of time to understand the research problem (research topic statement) and to define the research scope and direction. The 11 cases spent 6 to 8 months (i.e., first two or three face to face meetings) in general for this initial alignment.

Besides these typical alignment activities, the interviewees of 5 cases particularly reported that they had some alignment issues during the scoping phase. The types of alignment issues that these cases experienced were; first, alignment of the perspectives

between different organizations, for example, owner and contractor members (Distinguished cases D2 and D3); second, alignment around the research scope (Established case E2 and Atypical case A3); and third, alignment with CII (Special case S2).

One interviewee of the Distinguished case D2 commented that *"the biggest challenge*" during the alignment process *"was getting an agreement between contractors and owners around"* the research topic and deliverables. The interviewees of the case D3 mentioned that the team had some *"rivalry discussions"* due to the different perspectives between owner and contractor members. Nonetheless, all of these interviewees recollected that those conflicts were *"constructive"* rather than *"destructive"*. Another interviewee of the case D2 also recollected that investing *"so much time in the beginning for alignment"* was helpful for the team. What is implied from these interviews, even though it was challenging for the cases to align different perspectives of members, conflicts appeared to trigger discussions within the team providing an opportunity to explore various viewpoints for the research topic.

These type of alignment issues is inherent and expected in collaborative academia-industry research since one of the attributes in Mode 2 knowledge production is heterogeneity and organizational diversity (Gibbons et al., 1994). The key is to manage and handle these expected alignment issues in a *"constructive"* way so that the agreed research scope and objectives encompass diverse and heterogeneous perspectives of participating organizations.

The second type of alignment issues was alignment around the research scope. The alignment process in the initial phase of the cases normally included defining the research scope which would take a team two to three face-to-face meetings as discussed

earlier. However, the two cases, E2 and A3, experienced a more difficult alignment period than the other cases. In the case of E2, the team had *"volatile"* discussions to define the research scope because a new scope *"surfaced"* during this alignment period. As a result, the team eventually decided to pursue the new scope in addition to the existing scope, and they also agreed to split the team into two groups to conduct two separate research studies accordingly.

Unlike the case E2, which had alignment issues within the team in regard to the newly emerged research scope, the case A3 had difficulty in clearly defining the original research scope and establishing the clear research direction. Consequently, the team members were not fully aligned around the research scope and direction. One interviewee of this case recalled that the team was not actually aligned even after they developed a formal charter. This interviewee further elaborated that several *"strong"* team members *"drove the direction of the team"* and the rest of the team *"passively agreed"* even though they *"did not fully agree to that direction"*. This may have been related to the nature of their research topic. All the interviewees of this case noted that their research topic was not clear and it was very difficult to understand what the team was expected to pursue. Another interviewee of this case recalled that the team *"struggled with"* the essential question defined in the research topic statement, and it was not until *"75% of the research time"* had elapsed that the team *"really narrowed the focus* [research scope] *down"*. It is more probable that the team started to *"narrow the focus down"* even though the scope was still unclear to the team members because the team was running out of research time. Therefore, it is likely that improved clarity of a research topic and research problem provided to a team may reduce the issues and conflicts during the scoping phase.

The third type of alignment issue was alignment with a funding agency. Kulatunga et al. (2010) found that considering requirements of funding organizations is one of critical success factors during the initial and conceptual phases of collaborative academia-industry research in construction management. CII both provides the research topic in a standardized research topic statement and monitors research progress of each research team. Therefore, it is important for a team during the scoping phase to fully understand the given research topic statement. One of the Special cases, S2 had an alignment issue with CII in regard to the research scope – essential question. The industry team members decided to take a different direction from one stated in the original research topic statement. As a result, the research scope of this case changed as the original essential question changed.

7.5.1.2 Scoping – scope change

Finding I-2. Scope changes only appeared in two of the 11 cases.

In terms of scope change, only two cases changed their research scope; the Established case E2 and the Special case S2. The other cases did not change the scope once the team members agreed and aligned around the research scope and direction. An advantage that these two cases had with respect to scope change was a longer research period than a typical CII research effort. Considering that the 11 cases generally spent six to eight months in scoping and alignment, it would have been very difficult for the recent research teams to decide to change the scope and to obtain approval given the normal research time allowed of only 2 years.

7.5.1.3 Scoping – summary

Previous studies found clear establishment and agreement of research purpose and objectives by a team as factors for collaborative academia-industry research (Barnes et al., 2006; Kulatunga et al., 2011; Littler et al., 1995; Mora-Valentin et al., 2004; Pinto & Covin, 1989). Nevertheless, the previous studies did not discuss alignment thoroughly. Alignment can appear in various aspects while sharing and agreeing the objectives and direction. These may include aligning different perspectives of the members from different organizations, aligning on the research scope, or it could be external to the team, for example, with a funding organization. Some alignment processes can be constructive, inducing deeper understanding of the research topic providing a firm ground for the research process afterwards. Another possibility is to create a new research effort as seen in the case of E2. On the contrary, ineffective and unproductive alignment can delay the research process as well as diminish motivation and commitment of team members as in the case of A3. Thus, it is necessary to give a profound look at the alignment process and its impact on the performance of the whole research process of a collaborative academia-industry research team.

7.5.2 Data collection and analysis – multiple data collection methods and sources

Finding I-3. The Atypical cases did not use multiple data collection methods and sources.

Finding I-4. 5 cases had a difficulty in collecting a sufficient amount of data.

A mixed method approach, using both quantitative and qualitative research methods, has been suggested to improve the research quality, validity and reliability for construction management research (Abowitz and Toole, 2010; Amaratunga et al., 2002). Moreover, data collection from multiple methods and/or multiple sources, which is called

triangulation, helps researchers to extend the scope of theory in construction research (Love et al., 2002). Thus, it is important to consider research methods in assessing the research process.

The data collection methods of the 11 cases include survey, interview, case study, and workshops according to their research reports submitted to CII. All but the Atypical cases combined two or more methods for collecting data using different data sources. This is consistent with the previous studies emphasizing the use of multiple research methods in construction engineering and project management research (Abowitz & Toole, 2010; Amaratunga et al., 2002; Azhar et al., 2010; CII, 2010; Green et al., 2010; Love et al, 2002; Phelphs & Horman, 2010; Sillars &Hallowell, 2009). Data collection using multiple methods and/or sources, which is called triangulation, helps researchers to extend the scope of theory and to provide reliable solutions to complex problems that the construction industry faces (Love et al., 2002). In fact, this approach can also lend an opportunity to secure rich data and information that might be used to develop an implementation resource. It should be noted that most of the cases that utilized multiple research methods and data sources did deliver an implementation resource. In particular, 5 of the 8 recent cases (i.e., Distinguished, Atypical, and Special cases) reported the difficulty of collecting sufficient amount of data within the limited research time. Considering this difficulty, collecting data from multiple sources may mitigate the relatively lesser amount of data and increase the reliability of the research conclusions drawn from the data.

7.5.3 Others – industry background studies

Finding I-5. Industry members in 8 cases participated in background studies.

An interesting finding was that some industry team members participated in background studies during the scoping phase as part of the literature review. They would read previous CII studies or journal articles, and/or made presentations to the team of their company practices relevant to the research topic. One of the several academic interviewees, who commented that the industry background study was helpful, noted that it was an effective way to *"quickly engage the team (industry members) and to get work done between meetings"*. Thus, this could be a useful practice for engaging industry members from the early phase of research as well as to help members better and quickly understand their research topic area.

7.5.4 Others – evolving nature

Finding I- 6. "Evolving" nature of the research scoping and methodology development process was mentioned in 2 Distinguished cases and 2 Established cases.

"Evolving" nature of the research process in the scoping phase emerged during the course of the interviews. The interviewees of the two Distinguished cases and two Established cases indicated that the research deliverable design, research plan and research methodology in the scoping phase *"evolved through"* as the team discovered findings through the course of the research process. Previous studies included flexibility as one of success factors in collaborative academia-industry research. However, they provide little discussion in comparison with planning, scheduling and management of the research process (Barnes et al, 2006; Butcher & Jeffrey, 2007; Kulatunga et al, 2010; Littler et al., 1995; Sicotte & Langley, 2000).

Nonetheless, understanding the evolving nature of the research process can be as important as research planning and scheduling. The research team members may need to be aware of this *"evolving"* nature so that they can be flexible to change their research methodology or plan as their research unfolds. This attitude can also help to introduce new or innovative ideas or research methods into the team. For example, the interviewees of the case E2 noted their unique data collection method. It was a workshop approach, and according to the interviewees, their team was the first who adopted the approach as a data collection method in CII research. The interviewees recalled that this workshop approach *"just emerged"* during the team discussions. This may be a good example of the research team being ready to accept evolving and changing nature of the research process and willing to accept even a new research method.

7.6 EMERGING FINDINGS – II. TEAM DYNAMICS

The key findings in regard to team dynamics are summarized as below (see Table 7-4). Each of these thirteen findings will be discussed in detail in the subsections.

1. Team Composition
    - II-1. All the cases perceived that they had team members with good expertise, experience and background for their research topics.
    - II-2. Only 2 cases considered that they had good diversity.
2. Participation and Commitment
    - II-3. 4 cases perceived that they did not have a team attrition issue. 2 Atypical cases perceived that they had a significant attrition problem.
    - II-4. A majority of the 11 cases reported that they had a core group of members who actively participated in and were involved with research activities.

II-5. 5 cases perceived that they had strong member participation, and all the 3 Distinguished cases perceived that they had strong participation.

II-6. Leadership and value of the research perceived by the team were most frequently mentioned as key factors driving member participation. Effective meeting operation and members' interest and passion in the research topic also motivated member participation.

3. Subgroup Approach

II-7. 7 cases used a subgroup (sub-team or sub-committee) approach on a regular or ad-hoc basis as a means of task organizing to accomplish work.

II-8. 3 cases adopted a subgroup (sub-team or sub-committee) approach on a regular basis from the start.

4. Leadership

II-9. 3 cases characterized the leadership orientation as balanced between industry and academics. All of the Established cases recollected that their teams were industry-led.

II-10. 7 cases considered that their industry chairs were strong. Of significance, none of the Atypical cases perceived that they had strong chairs.

II-11. 6 cases perceived that they had strong PIs. Of significance, none of the Atypical cases perceived that they had strong PIs.

II-12. 6 out of 9 cases with multiple PIs reported that there was good alignment between PIs.

II-13. 5 cases recollected that they separated leadership roles and responsibilities between the co-chairs and the PIs.

II-14. 5 cases reported that they had regular leadership communications. All of the Established cases recollected that they had leadership communications on a regular basis. Of significance, none of the Atypical cases recalled they had regular leadership communications.

5. Team Relationship

II-15. 7 cases perceived that they had good relationships among members.

II-16. 7 cases recollected that they had no personal conflicts.

6. Team Management

II-17. 7 cases commented that the academics (either PIs or graduate students) kept meeting notes.

II-18. 6 cases recalled that the meetings were led by industry. 4 cases recollected that the PIs led the meetings.

II-19. 7 cases had social activities such as team dinners.

II-20. 5 cases particularly commented that they had good graduate research assistants whereas 2 Atypical cases mentioned about the graduate students and an Atypical case noted the poor performance of their graduate student.

From the key findings above, the apparent differences between the Distinguished cases and the Atypical cases are team attrition, member participation, use of subgroup, and leadership.

7.6.1 Team composition

Finding II-1. All the cases perceived that they had team members with good expertise, experience and background for their research topics.

Finding II-2. Only 2 cases considered that they had good diversity.

All the cases perceived that they had team members with experience, knowledge and expertise. Besides, when asked about strengths of the team, the team members with experience, knowledge, expertise, and backgrounds necessary for the research topic was mentioned as one of the strengths across all the 11 cases. Thus, it can be inferred that the CII research teams generally have team members with experience and expertise related to the research topic. This is mainly due to the fact that the member companies send team members with expertise and experience relevant to a given research topic. On the other hand, CII research teams may need more diverse members within the context of a given research topic since diversity may introduce various perspectives and new ideas into research contents. For example, exchanging ideas between members from different industry sectors or different generations can provide an opportunity to explore a given research topic from various aspects.

This aspect, having team member with knowledge and experience, is well aligned with previous studies. A number of researchers noted that selecting competent industry members with knowledge and expertise on a research topic as a success factor in collaborative academia-industry research (Amabile et al., 2001; Barnes et al., 2006; Davenport et al., 1999; Kulatunga et al., 2010; Shubert & Fisher, 2009). Nonetheless, diverse team composition has been little addressed in such studies. The interviewees perceived more diversity in team composition was desirable, particularly if a research topic required such diversity.

One interviewee of the case A3 commented that they had a difficulty in exploring the research topic since the team members were more of *"project management experience"* and *"task-oriented"* while their research topic required *"to be creative"*.

The industry interviewee of the case E2 also recommended to *"get the necessary experience with the mixture of people who think young"* to introduce *"new ideas"* into the research. Therefore, diversity in team composition may be an important factor for research success when a research topic involves innovative and creative approaches or new points of view than a traditional way of thinking.

7.6.2 Participation and commitment

7.6.2.1 Team attrition

Finding II-3. 4 cases perceived that they did not have a team attrition issue. 2 Atypical cases perceived that they had a significant attrition problem.

The interviewees of the cases A2 and E3 reported that the team had significant attrition, which was a problem from their recollection. From the analysis of the team rosters and the team member lists on the research summaries of the 11 cases, only the case D3 and S1 had little attrition, just one or two members dropping out the team. The 3 Established cases had 25 to 32% of attrition rates and the case D1 had approximately a 20% of attrition rate. The cases D2 and S2 lost one-third of the original team members. However, it should be noted that the case D2 started with more than 30 industry members, which was one-third more members than a typical CII research team has, and the case S2 was a six-year research program. For these two cases, it might have been unavoidable to have a certain degree of team attrition. The cases with more than 50% of attrition rates were the Atypical cases A1 and A2. Although the case A3 did not experience a significant attrition, one interviewee of the case A3 noted that the *"participation lessened*

towards" the end of the research process because the members did not clearly see the research direction.

The team attrition is certainly one indicator of team performance. However, it should not be considered as a single indicator for assessing team participation since other factors, such as economic downturn, can also affect team attrition. Thus, it is more reasonable to combine the team attrition with other factors such as meeting attendance or number of members in the core group for assessment of team participation and commitment.

7.6.2.2 Core group

Finding II-4. A majority of the 11 cases reported that they had a core group of members who actively participated in and were involved with research activities.

A concept 'core group', which was not part of the initial interview questions, emerged during the pilot interview, and this theme was then included in the interview questions. The interviewees were asked if their team had a core group, the industry members who continuously and actively participated in the research process.

The number of people in such core group ranged from 4 to 13 excluding the academics depending on the team size. From the analysis of the available face-to-face meeting minutes of 5 cases, the number of industry members who participated in more than half of the face-to-face meetings ranged from 7 to 12 excluding the academics. This indicates that the 'core group' was perceived as the team members who participated in at least half of the face-to-face meetings.

One interesting point in regard to the core group was found in the comments by one interviewee of the Atypical case A3. This interviewee recollected that 4 or 5 core people *"dominated the discussions"* and were aligned with the lead-PI. The interviewee further recollected that the rest of the team *"passively agreed"* with the core group even though they *"did not feel right about that direction"* and *"did not fully agree with that direction"*. This comment may imply that there exists a possibility of a core group dominating the research direction when team meetings are not facilitated to reflect the ideas of the less outspoken members. The industry interviewee of the Established case E2, who played a facilitating role in team meetings, described meeting facilitation as *"controlling loud dominators and bring in other ideas of the other people"*. Thus, it is important to keep the core group of people as well as to encourage less active members to make contributions. To achieve this, a research team can designate a facilitator within a team or team leaders, either industry leaders or academic leaders, can act as a facilitator.

7.6.2.3 Member participation

Finding II-5. 5 cases perceived that they had strong member participation, and all the Distinguished cases perceived that they had strong participation.

All of the Distinguished cases recollected that they had strong industry participation. The interviewees of these three cases commonly mentioned that the industry members actively participated in discussions and research activities. On the contrary, the common notion made by the interviewees of the Atypical cases was that they had strong and active participation in the beginning and it *"deteriorated"* and *"lessened"* as research progressed. Factors of such deterioration of member participation

included the issues with the lead-PI (A1), economic downturn (A2), and difficulty in establishing the research direction (A3) according to the interviewees of the three Atypical cases.

7.6.2.4 Factors of participation

Finding II-6. Leadership and value of the research perceived by the team were most frequently mentioned as key factors driving member participation. Effective meeting operation and members' interest and passion in the research topic also motivated member participation.

The interviewees were asked to provide some important factors of industry participation and commitment of their team from their perspectives. Various factors were mentioned including member interest and passion in the research topic, leadership, value and benefit of research recognized by team members, learning, productive and effective meetings, having fun, member relationship, team dynamics, alignment, company support, research schedule, and economic factors. The factors that were most mentioned by the interviewees of 7 cases were leadership and value and benefit of research recognized by the members. Effective meeting operation and members' interests and passion in the research topic were also mentioned from approximately half of the 11 cases. This finding implies that the interviewees identified these factors had a significant impact on member participation.

As discussed in Chapter 3, a number of previous studies noted that member participation and commitment as a key success factors for collaborative academia-industry research (Barnes et al., 2006; Butcher & Jeffrey, 2007; CII, 2010; Davenport et al., 1999; Kishchuk, 2005; Kulatunga et al., 2011; Littler et al., 1995; Mora-Valentin et

al., 2004; Stokols et al., 2008). However, few studies explored what aspects promote or lessen member participation and commitment in such collaborative research. Further, the relations between member participation and key success factors, such as leadership, have not been well addressed in extant literature. Thus, this finding provides a new avenue for future research in improving collaborative academia-industry research.

7.6.3 Subgroup approach

Finding II-7. *7 cases used a subgroup (sub-team or sub-committee) approach on a regular or ad-hoc basis as a means of task organizing to accomplish work.*

Finding II-8. *Just 3 cases adopted a subgroup (sub-team or sub-committee) approach on a regular basis from the start.*

The 11 cases utilized a subgroup approach to organize research tasks. As the interviewees described the subgroup approach as *"divide and conquer",* they broke up the team into several smaller groups of people to accomplish tasks. Such tasks included initial literature review, writing up research documents, and preparing the presentations for the report out at the Annual Conference. However, except for the case of E2, which divided the team into two groups to conduct two different research efforts, only 2 cases employed the subgroup approach from the start. The rest of the cases used this approach as needed.

This subgroup approach is a useful practice to encourage member participation as well as *"divide and conquer"* the research tasks. The academic interviewee of the case D1, which adopted the subgroup approach from the beginning and maintained throughout the process, commented that the approach *"worked very well"* for a large group such as their team. The interviewee further commented that the subgroup approach *"took the*

pressure off" the academic and *"the two co-chairs in trying to keep everyone* [team members] *busy"* because the subgroups *"kept* [team members] *themselves busy"*.

Further, alignment between subgroups emerged as important. One academic interviewee of the Special case S1, which formed the subgroups in preparing the research products and the conference presentations, commented that the subgroups *"worked independently and had independent meetings during the last six months"* of the research process. This interviewee noted that the team had *"some misalignment between subgroups",* which might have cost the team *"a little bit of time"* because the team did not have an *"alignment check for a couple of months"*. Nevertheless, the interviewee considered the subgroup approach was *"very effective"* for their team.

The subgroup approach is likely to be a useful and effective practice to encourage member participation and engagement through assigning tasks to industry members. It seems more effective for a larger group, such as the case D2, assisting team leaders in managing the team and maintaining team member involvement in the research process. In adopting this subgroup practice, it is recommended to have frequent alignment checks between subgroups.

In the previous studies on collaborative academia-industry research, they have focused on success factors or determinants rather than practices that research participants can actually apply to their research process for improving the performance. This study also focuses on the key attributes and success factors. However, during the analysis, this subgroup approach emerged as a useful practice to enhance member participation.

7.6.4 Leadership

7.6.4.1 Leadership orientation

Finding II-9. 3 cases characterized the leadership orientation as balanced between industry and academics. All of the Established cases recollected that their teams were industry-led.

In a typical CII research team, a single or a couple of academics take leadership on the research side, and two co-chairs appointed from industry members provide the overall leadership of the whole process (CII, 2013). Because of its emphasis on the industry leadership on a team (CII, 2010), it was decided to investigate leadership orientation of the 11 cases. The interviewees were asked to characterize the leadership of their team, whether it was industry-led, academic-led, or balanced.

Only 3 cases were considered their leadership as balanced between the industry members and PIs. All of the Established cases and the case A1 characterized that the team was industry-led, and the case D2 was academic-led. The lead-PI was replaced in the case of A1, and the case D2 experienced change of both co-chairs, and therefore, it was not unpredicted that the case A1 was industry-led and the case D2 became academic-led. The remaining 3 cases (A2, A3, and S1) provided mixed perceptions. Some interviewees viewed their team as academic-led while other interviewees perceived the leadership as balanced within a case. This may imply that the leadership of these three cases was slightly more on the academic side or relatively balanced.

Interestingly, all of the Established cases were perceived by the industry-led. One possible explanation could be the fact that the Established cases had only one industry chair whereas the other cases, more recent teams, had two co-chairs on the team. Having a single point of responsibility could create a central leadership. Another possible

explanation could be that 4 of 5 interviewees of the Established cases were academics, and the academic interviewee might have tended to describe their team as industry-led. Apart from the 3 Established cases, it is concluded that the recent cases in general had balanced and mixed leadership from both industry and academics unless they had radical changes in industry or academic leadership as seen in the cases D2 and A1.

While there is a study emphasizing academic leadership in a collaborative research (Kulatunga et al., 2011), the leadership orientation and its influence on team performance has not been explored in the previous studies. The previous studies regarded alignment and collaboration as a key success factor in collaborative academia-industry research (see Table 2-2). To achieve such alignment around common objectives and vision and true collaboration between academics and industry members, it is of necessity to control individuals who try to dominate the research direction. As several interviewees commented, it should be *"equal partnership and leadership"* and *"group effort"* not having one side (industry or academic) who are *"forceful"* and directing what to do and what to be done.

7.6.4.2 Industry chair leadership

Finding II -10. 7 cases considered that their industry chairs were strong. Of significance, none of the Atypical cases perceived that they had strong chairs.

The interviewees of the cases D2 and A3 responded that they had issues with chair leadership. The interviewees of the cases A1, A2, and S1 reported mixed views to chair leadership, which means that some interviewees of the case viewed their chairs were strong while other interviewees of the same case considered opposite. One notable

point is that the interviewees of the cases with chair leadership issues mentioned that their chairs did not fully understand the roles and responsibilities of chairs. This reveals that understanding the expected roles and responsibilities of industry chairs plays a critical role in proper execution of the role in a collaborative academia-industry research environment. Since in most cases there are dual leadership points within a team, academic and industry, it is likely that industry leaders tend to delegate their roles and responsibilities to academic leaders unless they clearly understand their roles and responsibilities.

The interviewees were also asked to describe their chairs. Some characteristics provided by the interviewees when they described their industry chairs as strong are grouped and summarized as below.

- *Leader skills*: Had good leadership, organizational skills, and good communication styles, set the expectations, knew when to listen and when to decide and take actions, performed leadership by example
- *Management skill*: Kept the team on track, made sure to get things done, kept the team heading the right direction, kept the team focused
- *Personal attributes*: Understood team dynamics, kept the team together, responsible, dedicated, had good personalities, active, outgoing, having substantial industry experience
- *Collaboration with PIs*: Worked well with the PIs.
- *Understanding of the collaborative research process*: Had a right balance between influence (control) and freedom (research freedom)
- *Compatibility*: Respected by the team members, complementary styles between two co-chairs

Some characteristics used by the interviewees when they described their industry chairs as not strong are grouped and summarized as below.

- *Leader skills*: Too occupied with company job, and did not participate in all the meetings
- *Personal attributes*: Opinionated
- *Understanding of the collaborative research process*: Felt uncomfortable in the research environment
- *Understanding of roles and responsibilities:* Struggled with the leading roles and responsibilities, did not know what to do as co-chairs, not demanding

In summary, it appears that industry leaders need to know and understand the roles and responsibilities as a leader of a collaborative academia-industry research team. These roles and responsibilities can be pre-defined as CII does or they can be defined through alignment with academic researchers. Either way, it is likely that without knowing the appropriate roles and responsibilities, it would be difficult to be a strong industry leader. In addition, the industry leaders may need some level of experience in leading a team with understanding of team dynamics. Since a collaborative academia-industry research team is typically comprised of people from different backgrounds, experience, expertise, and personalities, it is essential to understand the team dynamics in maintaining the team as a whole and enhancing synergetic effect.

Industry leaders are expected to show some facilitation and management skills as well. While letting the team explore various perspectives and exchange opinions concerning the research topic, the leaders need to know when to make decisions and keep

the team focused on the right direction. The industry interviewee of the case E2, who facilitated the team meetings, recollected that his main job was *"controlling loud dominators and bring in other ideas of the other people and making sure they are accepted"*. He further suggested having a *"good facilitator"* for a team to *"make a highly productive team and get a high degree of involvement"*.

7.6.4.3 Academic PI leadership

Finding II -11. 6 cases perceived that they had strong PIs. Of significance, none of the Atypical cases perceived that they had strong PIs.

Finding II -12. 6 cases out of 9 cases with multiple PIs reported that there was good alignment between PIs.

The industry interviewees of all Distinguished cases and Special cases described their PIs positively. The industry interviewee of the Established cases E2, the only industry interviewee of the Established case interviewees, also characterized the PI of the case E2 as *"a good leader"*. Three Atypical cases, A1, A2, and A3 did not perceive their PIs as strong. In the case of A1, where the lead-PI left the team, both interviewees criticized the lead-PI for the reason that the way of leaving the team caused deterioration of team participation and commitment. The industry interviewees of A2 appeared to have the mixed views of the PIs. One industry interviewee said that *"the PIs did a good job"* while another industry interviewee characterized that *"the academics were not strong"*. In the case of A3, the two industry interviewees did not particularly characterize the PIs as strong or weak. However, both industry interviewees thought that the lead-PI led the research direction to *"his agenda"*.

Some characteristics used by the interviewees when they described their PIs as strong are summarized as below.

- *Leaders skill*: Used individuals effectively to help the team dynamic
- *Management skills*: Organized, kept the team informed, prepared, structured, proactive
- *Personal attributes*: Passionate and enthusiastic, open, listening, honest, transparent, persistent, had industry background and experience, had CII research experience, had personal interactions and relationships with the team
- *Facilitation skill*: Provided a safe environment for open discussions

Another aspect in regard to the academics emerged was the alignment between the two PIs. A typical CII research team may have more than one academic researcher. The benefits of having multiple academics include providing a team with *"different perspectives and ideas"* as well as the academics are *"bouncing ideas off each other"*, as some interviewees mentioned, which in turn could bring richness to the research.

Nevertheless, alignment between multiple academics can be problematic. The Distinguished case D2 had such problem. The industry interviewees of this case mentioned that the lead-PI and the co-PI were not aligned and the co-PI was not aligned with the rest of the team, either. One interviewee of this case recollected that *"it was very difficult at the beginning with the two academics because it was clear that there were two separate purposes"*. Therefore, it is important to make sure the academics are aligned, if there are multiple academics involved, to prevent the team members from being confused and distracted, and, consequently, delaying the alignment process of the whole team.

7.6.4.4 Leadership roles and responsibilities

Finding II -13. 6 cases recollected that they separated leadership roles and responsibilities between the co-chairs and the PIs.

Of the 11 cases, 6 cases established separate leadership roles and responsibilities between the industry chairs and PIs. The Atypical cases A2 and A3 commented that they did not establish the roles and responsibilities between the chairs and PIs. It is interesting that these 6 cases with separate leadership roles and responsibilities were also the cases with strong chairs except E1. The case E1 did not exactly recollect the team separated the roles and responsibilities between the chair and PIs since it was more than 30 years ago.

7.6.4.5 Leadership communications

Finding II -14. 5 cases reported that they had regular leadership communications. All of the Established cases recollected that they had leadership communications on a regular basis. Of significance, none of the Atypical cases recalled they had regular leadership communications.

All the Established cases recollected that they had leadership communications on a regular basis. Besides these three, only two cases (D3 and S2) had such formal leadership communications. The other cases had ad-hoc leadership meetings or conference calls as needed. One of the academic interviewees of the case D3 recollected that they had good agenda for every meeting since the PIs and the co-chairs always communicated in preparation for the team meetings.

7.6.5 Team relationship and management

Finding II -15. 7 cases perceived that they had good relationships among members.

Finding II -16. 7 cases recollected that they had no personal conflicts.

Finding II -17. 7 cases commented that the academics (either PIs or graduate students) kept meeting notes.

Finding II -18. 6 cases recalled that the meetings were led by industry. 4 cases recollected that the PIs led the meetings.

Finding II -19. 7 cases had social activities such as team dinners.

Finding II -20. 5 cases particularly commented that they had good graduate research assistants whereas 2 Atypical cases mentioned about the graduate students and one of the Atypical case noted the poor performance of their graduate student.

Previous studies included team relationship as a success factors in collaborative academia-industry research (Amabile et al., 2001; Barnes et al., 2006; Davenport et al., 1999; Kishchuk, 2005; Litter et al., 1995; Mora-Valentine et al., 2004; Sicotte & Langley, 2000; Stokols et al, 2008). Of the 11 cases, 7 cases perceived that their team maintained overall good relationships between team members. The interviewees of the cases having a good relationship described that their team members had respect, trust, openness, and cohesiveness among the members. However, the cases D2 and D3 experienced some conflicts due to a couple of opinionated members with strong personality, which in turn resulted in a longer alignment process in the scoping phase. The interviewees of the case E1 did not particularly mention respect, trust, openness or cohesiveness of the team

members. However, the interviewees recalled the team did not have any *"interpersonal conflicts"*.

The cases A1and E2 reported that the team relationship was not good. The interviewees of E2 recollected that the team members had conflicts over the research direction. The industry interviewee said that those conflicts *"got personal"* and *"hurt the relationship"*. The academic interviewee of A1 mentioned that the team relationship between the core members *"was not really good"*. The case A2 had a mixed view in regard to the team relationship. One of the industry interviewees recalled that the team had a good relationship while another industry interviewee recollected that the team did not have *"enough chance to know each other due to the economic issue"*.

In terms of meeting minutes, 7 cases reported that they kept meeting minutes by either PIs or graduate students. All of the Established cases and 2 Distinguished cases reported that meeting facilitation was provided by industry. The academics led the team meetings in the cases D2, A3, S1, and S2. In terms of social activities, seven recent cases had some social activities, such as team dinner after face-to-face meetings. The interviewees of the Established cases did not particularly recollect they had such social activities, which might have been due to different meeting practices when the Established cases conducted research or simply because the interviewees did not recall such details.

The interviewees of 5 cases particularly mentioned about their graduate research assistants describing as *"great"* and *"excellent"*. The case A1, on the contrary, had difficulty with the graduate student assigned to the team. The academic interviewee of the case commented that the student was not *"qualified to do statistical analyses on survey data collected"* with *"no engineering or statistical background"*. In fact, the industry interviewee of this case reported that *"some data were lost"* after the lead-PI left the

team, which *"broke down the morale of the team"*. Considering the role of graduate students in a collaborative academia-industry research, which includes data collection and analysis, having a competent and skilled graduate student on a team is an important factor for smooth research process.

7.7 EMERGING FINDINGS – PRODUCT DESIGN AND DEVELOPMENT

7.7.1 Key findings

The key findings in regard to product design and development are summarized as below.

III-1. 4 cases reported that the industry members were involved in writing the research product (RS).

III-2. The interviewees of 9 cases perceived that they produced good quality products.

One of the interview questions regarding product design and development was key considerations when the teams were developing the products. The responses of the interviewees are summarized as below.

- Usefulness, usability, clarity, practicality, applicability, timing, user-friendly
- Relevance to the industry, and satisfying the academic rigor
- Value to the member companies
- Target audience
- Compatible with what industry thinks
- Meeting research objectives

When asked if the industry team members were involved in writing the research summary or implementation resources, only 4 cases responded positively. CII requires that a research summary is written by industry team members to maintain industry focus and voice on the summary. However, it appears that not every research team writes the research summary in such a way. One of the academic interviewees commented that *"in theory industry writes the research summary and academics write the research report.* [However, it] *never works that way"*. The interviewee further elaborated that the PIs drafted the research summary and *"gave the industry members to edit and review for accuracy and relevancy"*. Another academic interviewee also commented that *"it is a misperception"* that *"industry writes the research summary"*.

In terms of product quality perceived by the interviewees, the interviewees of the all the cases except two Atypical cases commonly perceived that they produced quality products and they were satisfied with their deliverables. Among the Atypical cases, only one case, A2, expressed that they delivered good quality products, and there were mixed views from the interviewees to the product quality in the other two Atypical cases.

This assessment on the product quality was from the interviewees as well as from the e-copy downloads and hardcopy sales of each product of the 11 cases. Table 7-6 presents the initial dissemination analysis of the product downloads and sales. The purpose of this analysis was to assess the level of initial dissemination and acceptance of the research products of each case by CII member companies.

Since the products of the recent cases have not been available to CII member companies before 2009, the product downloads and sales data 2009 to 2012 were collected for comparison. The number of product downloads and sales of each case were

normalized by the number of years the products were available to the users and the number of products that a case produced and currently available to users.

Case category	Distinguished			Atypical			Established			Special	
Cases	**D1**	**D2**	**D3**	**A1**	**A2**	**A3**	**E1**	**E2**	**E3**	**S1**	**S2**
# of products available online	3	3	3	2	1	2	2	5	2	3	10
# of downloads/sales per product	67	104	33	79	N/A	99	40	78	25	36	62
Average by case category	68			89			48			49	

* N/A: Not Available

Table 7-6: Normalized Dissemination Data by Case

As shown in Table 7-6, there appear no apparent differences between Atypical cases and the other cases. In fact, the immediate product dissemination appears stronger in the Atypical cases. On the other hand, the Established cases still maintain strong dissemination. The numbers of downloads and sales for the Established cases represent long-term dissemination since those cases produced outcomes at least more than 10 years ago. This finding illustrates that short-term or initial dissemination of a research product does not necessarily indicate its quality or research success. Rather, this finding corroborates that the long-term dissemination is in fact a strong and reliable indicator of research success and quality products.

7.8 SUMMARY

This chapter discussed the process and findings of the first part of the cross-case analysis. The analysis approaches used were pattern analysis and content analysis. These

two analysis methods were applied to the data of the 11 cases validate the research propositions. Of the 11 research propositions, 7 propositions were supported, and 4 propositions were partially supported. The 4 propositions that were not fully supported were related to scope definition and alignment, breakthrough thinking, and product quality.

Emerging themes and concepts in regard to the three case subunits (i.e., research methodology, team dynamics, product design and development) were also identified in addition to the propositions. Those identified themes and concepts were analyzed and discussed in detail. The next chapter will discuss the process and findings of the second part of the cross-case analysis and suggest key attributes and success factors consolidated from the entire cross-case analysis.

Chapter 8: Comprehensive Cross-Case Analysis (II)

The purpose of this chapter is to provide the analysis on the additional interview comments other than the three case subunits. Such additional comments included lessons learned from the cases and general perspectives to successful collaborative academia-industry research of the interviewees. Furthermore, the findings of this analysis will be discussed in comparison with the cross-case analysis of the previous chapter and the literature review to identify if any additional findings emerge. Next, key process attributes and success factors from the consolidate findings of the two cross-case analyses will be presented.

8.1 CROSS-CASE ANALYSIS PROCESS (II)

This chapter provides discussions of the findings from the interview responses to the questions beyond three case analysis subunits, which are research methodology, team dynamics, product design and development. These additional questions consisted of lessons learned and success of collaborative academia-industry research.

The analysis process is illustrated in Figure 8-1. In the first step, individual interview comments were analyzed to identify words or phrases that were considered as emerging or core themes and/or concepts. Then, those words or phrases were organized around the three case subunits (i.e. research methodology, team dynamics, product design and development), corresponding proposition categories and interview question categories. In the third step, the organized themes and concepts were counted to assess the relative significance of each theme. The results were compared with the cross-case analysis of the previous chapter as well as the literature review. This analysis approach was applied to the analysis of both lessons learned and success of collaborative academia-industry research.

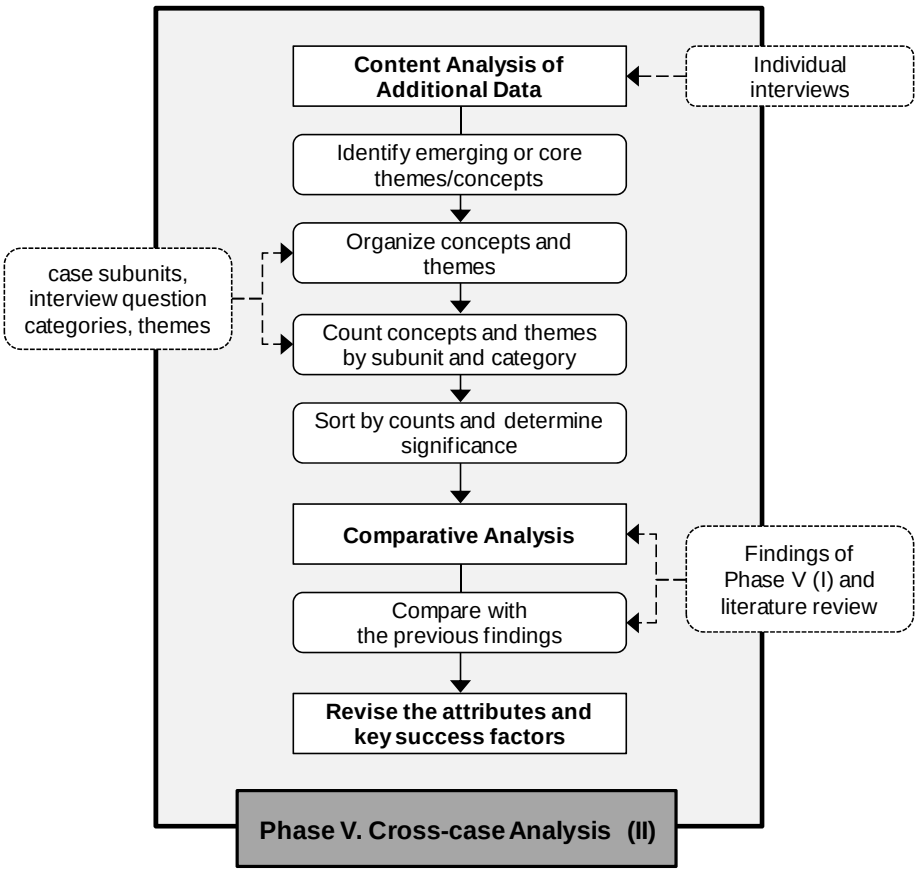


Figure 8-1: Cross-Case Analysis Process (II)

8.2 LESSONS LEARNED

The interviewees were asked to provide lessons learned from their experience with the case. The interview question was "What lessons learned could you offer to build upon this experience and help improve the experience and performance of other research teams?" 35 interviewees, 16 academics and 19 industry interviewees, from a total of 39 interviewees responded to this question. Note that not every interviewee provided lessons learned. One reason was an interview time constraint. The other reason that some interviewees did not provided separate lessons learned was that they provided this in

other responses. However, at least one interviewee from each case provided lessons learned.

The comments of each interviewee were analyzed to identify words, phrases or sentences that included meaningful concepts or information in regard to the three case subunits (i.e., research methodology, team dynamics, and product design and development). These words, phrases or sentences were further analyzed to be grouped into subcategories.

8.2.1 Lessons Learned by category

The content analysis approach was used to understand which area of the research process that the interviewees perceived more important than others in terms of the lessons learned from their experience with the cases. Table 8-1 summarizes the lessons learned sorted by the number of comments that appeared in the category. The number of comments in the third column in the table refers to the total number of comments that were categorized in 'Category Level 2', and is equal to the sum of the number of comments for each theme in 'Theme/Concept' column. For example, the number of comments for category 'Team management' of subunit 'Team Dynamics' is 16, which is a sum of the comments of the four themes that appeared in the fourth column. The number of comments for each theme is shown in parenthesis next to each theme. Note that the number of comments for each 'Category Level 2'does not necessarily represent the number of interviewees since a single interviewee could comment multiple themes in a same category.

Category Level 1 (case subunit)	Category Level 2	Number of comments	Theme/Concept
Team dynamics (69)	Team management	16 (D: 8, A: 0, E: 1, S: 6)	• time management (6) • communication (4) • meeting operation (3) • social activity (3)
	Interpersonal relationships	15 (D:3, A: 2, E: 1, S: 9)	• team focus/ relationships (6) • open-minded (6) • trust (3) • outspoken (1) • PI relationship (1)
	Participation	14 (D: 6, A: 3, E: 0, S: 5)	• active participation/engagement (10) • commitment (4)
	Leadership	14 (D: 5, A: 4, E: 2, S: 3)	• PI leadership (6) • chairs (3) • leadership balance between chairs and PIs (3) • roles & responsibilities (2)
	Team composition and diversity	10 (D: 5, A: 2, E: 0, S: 3) (D: 2, A: 4, E: 0, S: 4)	• diversity (4) • right selection of team members (3) • team size (2) • previous CII experience (1)

(D: Distinguished, A: Atypical, E: Established, S: Special)

Table 8-1: Rankings of Lessons Learned by Category Level 2

Category Level 1 (case subunit)	Category Level 2	Number of comments	Theme/Concept
Research methodology (19)	Topic/RTS	6 (D: 2, A: 2, E: 2, S: 2)	• right topic (2) • interesting topic (1) • clear topic statement (1) • narrowing the topic down (1) • difficulty of innovative research (1)
	Scope alignment	6 (D: 1, A: 1, E: 0, S: 4)	• understanding and alignment around scope (2) • a clear vision/expectations (2) • focused objectives (1) • wandering in the desert (1)
	Data collection	4 (D: 2, A: 0, E: 1, S: 1)	• survey planning and development (2) • access to data (1) • future publications (1)
	Research time	3 (D: 1, A: 1, E: 0, S: 1)	• not enough research time (3)
Others (9)		9 (D: 2, A: 4, E: 0, S: 4)	• coordination with CII, company support, funding, external factors, etc.
Total: 97 comments			

Table 8-1, continued.

On the other hand, the number of the comments for each theme is the number of interviewees who commented specifically about each theme. The total number of comments is 97, of which 69 comments were from the team dynamics side, 19 were from

the research methodology side, and 9 were from others. By case category, 35 comments were from the Distinguished cases, 19 from the Atypical cases, 7 from the Established cases, and 36 from the Special cases.

Table 8-2 is another way of sorting the category and themes found in lessons learned. At the theme level, the top theme is 'active participation and engagement', which was mentioned by 10 interviewees. The findings from this content analysis will be discussed in the subsections.

Category Level 1 (case subunit)	Theme/Concept	Counts (# of interviewees)		Category Level 2
Team Dynamics	active participation /engagement	10	(D: 5, A: 1, E: 0, S: 4)	Participation
	team focus /relationships	6	(D: 1, A: 1, E: 0, S: 4)	Interpersonal relationships
	open-minded	6	(D: 1, A: 0, E: 1, S: 4)	Interpersonal relationships
	PI leadership	6	(D: 2, A: 1, E: 1, S: 2)	Leadership
	time management	6	(D: 2, A: 0, E: 0, S: 4)	Team management
	communication	4	(D: 2, A: 0, E: 0, S: 2)	Team management
	commitment	4	(D: 1, A: 2, E: 0, S: 1)	Participation
	diversity	4	(D: 3, A: 1, E: 0, S: 0)	Team composition and diversity

(D: Distinguished, A: Atypical, E: Established, S: Special)

Table 8-2: Top eight Lessons Learned by Theme

8.2.2 Discussion of key findings

8.2.2.1 Lessons learned by category

As presented in Table 8-1, the top 'Category Level 2' is 'team management' with 16 comments, followed by, 'interpersonal relationships', 'leadership', and 'participation'. It is notable that team management emerged as a key lesson learned of the interviewees, which was not particularly found in the cross-case analysis in the previous chapter. One possible explanation for this is that the interviewees viewed team management as a key lesson learned that they wanted to offer for other research teams from the academic-industry collaborative research perspective.

One notable point is that while the interviewees of the Distinguished cases and Special cases noted team management as a lessons learned, only one interviewee from the Established cases and none of the Atypical cases commented about the team management aspect. Considering that only a small number of comments (7 comments) were made by the Established cases for all categories and the Established cases had more flexibility in terms of research time than the recent cases, it is not unexpected that the interviewees of the Established cases did not find lessons learned from team management. However, it is interesting that none of the interviewees of the Atypical cases identified lessons learned from the team management aspect. One possibility is that the interviewees of the Atypical cases attributed their team performance to other aspects, such as research topic, leadership or coordination with CII, more than team management.

Another interesting finding is that the interviewees of the Special cases viewed 'interpersonal relationships' as lessons learned for team performance more than the interviewees of the other cases. Of the 15 comments associated with 'interpersonal relationships', 9 comments were from the interviewees of 2 Special cases, and the other 6

comments were from the other cases. Moreover, 6 of those 9 comments came from the Special case S1. In the analysis of the previous chapter, both Special cases reported that they had no scope alignment issues and no personal conflicts within the team. This may imply that the interviewees of these two special cases were very well aware of the positive impact of the interpersonal relationships on the team performance. On the other hand, leadership was perceived by the interviewees across the11 cases.

8.2.2.2 Lessons learned by theme

In Table 8-2, 10 interviewees viewed active participation and engagement of the team members as a lesson learned. Of the 10 interviewees, 5 were from the Distinguished cases, 4 from the Special cases, and 1 from the Atypical cases. In the cross-case analysis of 'Team Dynamics' in the previous chapter, it was found that none of the Atypical cases reported that they had strong participation. It is notable that the interviewees of the cases with strong member participation perceived active participation as an important lesson learned. This may imply that the interviewees of the team with strong participation well recognized the benefits and critical role of strong participation in the research process. Team focus/people relationship, open-minded, PI leadership, and time management were also perceived as lessons learned by the interviewees across the 11 cases. From other themes and concepts, which were categorized in neither research methodology nor team dynamics, the interviewees of the Atypical cases noted 5 themes including communication with CII, coordination with CII, support from the team member companies (e.g., for traveling), and economic situation. It can be inferred that the interviewees of the Atypical cases tended to find lessons from outside the team.

8.2.3 Summary of key findings from lessons learned

The interviewees found more lessons learned in the team dynamics aspect than in the research methodology aspect. Among the lessons learned at the theme level, 'active participation and engagement' was identified by 10 interviewees, which was approximately 25% of the total 39 interviewees. Time management, interpersonal relationships, open-minded and PI leadership were mentioned by 6 interviewees. At the category level, the interviewees found it critical to have effective team management of which the themes include time management, communication, meeting operation, and social activity. This team management did not particularly stand out as key attributes or factors in the analysis of the previous chapter. However, the analysis of lessons learned by the interviewees indicated that effective team management needed more attention for its impact on team performance. People relationship, participation, and leadership were also perceived as important by the interviewees.

At the theme level, active participation and engagement of team members was most often identified as lessons learned by the interviewees. Team focus/people relationships, being open-minded, PI leadership, and time management were also noted as lessons learned from the interviewees. This finding is partially consistent with the first part of the cross-case analysis. Strong participation and PI leadership were clearly the features that distinguished the Distinguished cases from the Atypical cases from the cross-case analysis in the previous chapter.

8.3 SUCCESS OF ACADEMIA-INDUSTRY COLLABORATIVE RESEARCH

The interviewees were asked about their perspectives on the success of collaborative academia-industry research. The interviewees were first asked to define research success in academic-industry collaborative research in general, and second, key

success factors of such collaborative research from their perspective. In addition to these two questions, the academic interviewees (i.e., Principal Investigators of research teams) were asked their approach to keep the balance between academic rigor and industry practical relevance in a collaborative academia-industry research environment. The following subsections will discuss the interviewee responses to each of these three questions.

8.3.1 Definition of successful collaborative academia-industry research

A total of 31 interviewees, 11 academics and 20 industry members, provided their definitions of successful collaborative academia-industry research. Key themes and concepts were identified from the interview transcriptions, and those were categorized and sorted by the number of comments by category as shown in Table 8-3.

Seventeen interviewees considered that research success was defined by the 'implementability' (or applicability or usefulness) of research products. 'Industry impact' of research outcomes was mentioned by eight interviewees, and 'value' of the research product was mentioned by six interviewees. Therefore, it can be inferred that the interviewees perceived implementability, impact and value of research products as key criteria in defining success of collaborative academia-industry research. This finding is well aligned with the literature review in Chapter 2 in regard to success definition and success criteria for collaborative academia-industry research. Six interviewees defined research success as delivering research findings that would provide comprehensive and interesting answers to the research question and would include new ideas and different perspectives.

Rank	Category	Number of comments	Theme/Concept
1	research product – implementability	17	applicability, implementability, usefulness
2	industry impact	8	impact, benefits, improvement, needs
3	research product – value	6	industry value, quality
4	research findings	6	comprehensive, interesting, new idea, different perspectives
5	research topic	4	identify problems, relevant to topic
5	research product – quality	4	product quality, time/cost/quality
5	team	4	alignment, learning opportunity
5	academia and industry	4	mutual benefit, win-win effort
9	research methodology	3	credibility, problem definition
10	collaboration	2	common objectives
11	academia	1	use in classrooms

Table 8-3: Definitions – Academia-Industry Collaborative Research

In summary, it is probable that the interviewees viewed the success in collaborative academia-industry research as delivering research outcomes with a great chance to be implemented by industry with tangible and potential value that would bring impact to the industry.

8.3.2 Success factors of collaborative academia-industry research

The next interview question was about key factors to accomplish such research success based on their research team experience whether it was with these cases or other research teams on which they had participated. Key themes were identified from the interviews, and those were categorized and sorted by the number of comments of each

category as shown in Table 8-4. A total of 23 interviewees, 11 academics and 12 industry members, provided key success factors from their perspectives.

A majority of the comments provided by the interviewees belonged to team dynamics, which appeared to be consistent with the finding in the previous section, "Lessons Learned". The key success factor noted most were team composition and diversity. Some themes or concepts categorized in this factor includes the right mix of experience, background, and technology, people with actual experience in developing tools, personal traits and backgrounds, and team member qualifications. Several previous studies on key success factors of collaborative academia-industry research tried to prioritize the success factors (Davenport et al., 1999; Kulatunga et al., 2010). In their studies, 'selecting the right collaborative partner' or 'selecting a competent team' are relatively highly ranked.

Rank	Category	Number of comments	Factors
1	team dynamics	22	composition and diversity (9), interactions (4), roles and responsibilities (2), participation (2), chairs (2), leadership (1), PIs compatibility (1), GRA (1)
2	research methodology	8	data access (3), scientific rigor (2), validation (1), transparency (1), practicality(1)
3	research topic	6	interesting (2), challenging (1), new ideas(1), specific topic (1), time sensitive (1)
4	research product	6	usability (3), tool (3)
5	research scope	2	alignment (2)
6	others	4	listening, company support, openness, time pressure

Table 8-4: Key Success Factors – Academia-Industry Collaborative Research

Nevertheless, team composition and diversity did not appear as important features of successful cases in the cross-case analysis in the previous chapter. On the other hand, team composition and diversity were perceived as important lessons learned from the interviewees (see Tables 8-1 and 8-2). There is one probable explanation of this finding. Whether Distinguished cases or Atypical cases, the interviewees perceived they had good team composition and the right mix of people with experience and expertise because of the uniqueness of CII research. A CII research team consists of 15 to 20 industry members from CII member companies, typically all from different companies, and team members meet every two or three months for one and a half days solely devoted to research for a two year period. It is likely that the interviewees realized through their research experience that such a level of participation by diverse industry members with such experience and expertise with their valuable input play an essential role in accomplishing successful research. In summary, this finding implies that having a right mix of team members with a certain degree of diversity is likely to be a prerequisite of successful collaborative academia-industry research.

8.4 RIGOR VERSUS RELEVANCE IN ACADEMIA-INDUSTRY COLLABORATIVE RESEARCH

Only the academic interviewees were asked about balancing academic rigor and industry practicality in conducting collaborative academia-industry research. The actual question was 'How would you keep the balance between academic rigor and industry practical relevance?' Of the 17 academic interviewees, 10 interviewees responded to this question. The rest of the interviewees were not asked due to interview time limitation.

Table 8-5 summarizes 14 concepts and themes found in the comments from the 10 interviewees. Of these 14 concepts, 9 were related to research methodology, and 5

were related to the relationship between the industry and academics. It was expected that research methodology was emphasized in balancing academic rigor and industry practicality. An interesting discovery was that 5 interviewees noted the relationship between the PIs and industry members. The interviewees suggested that industry members need to understand and trust academics in keeping academic rigor. One of those 5 interviewees provided his insight regarding this relationship from his research experience with CII and other industry organizations. He perceived that the industry members were *"very tolerant and very supportive of more scientific and esoteric academic* [research] *projects"* as long as academics conduct research in their interest and produce *"really useful products"*.

Rank	Category	Number of comments	Theme/Concept
1	Research methodology	9	well-conceptualized methodology, validation, scientific method, credibility, sufficient data amount and input, developing theories from observations
2	Academia-industry relationship	5	trust and understanding from industry , academics keeping the control of rigor, producing mutually beneficial outcomes

Table 8-5: Academic Rigor vs. Practical Relevance

8.5 CONSOLIDATION OF THE TWO CROSS-CASE ANALYSES

The findings of cross-case analyses (I) and (II) were consolidated and organized into the conclusions. From the cross-case analyses, a total of 9 attributes were identified. Of these 9 attributes, 3 are associated with research methodology, 5 are connected with team dynamics, and 1 attribute is related to product design and development.

8.5.1 Key process attributes – Research Methodology

The key process attributes for research methodology include alignment, balancing academic rigor and industry practicality, and evolving nature. Table 8-6 summarizes these three attributes. These attributes are closely related to the two attributes of Mode 2 knowledge production; 1) transdisciplinarity and 2) heterogeneity and organizational diversity. Production of Mode 2 knowledge involves various "skills and experience" to solve a certain problem and produce practical knowledge, which is heterogeneity as defined by Gibbons et al. (1994). Production of Mode 2 knowledge is transdisciplinarity crossing the disciplines as well as boundaries of fundamental and applied science. Transdisciplinarity, therefore, is also part of the distinctive nature of Mode 2 knowledge production in establishing research resources as well as in communicating and evaluating research outcomes.

Alignment in the scoping phase was also identified as a key process attribute in collaborative academia-industry research from the analysis of the 11 cases. On a collaborative academia-industry research team, academics and industry practitioners work together to produce practical and applicable solutions to solve industry problems. The team members typically have diverse backgrounds and experience, and, depending on the research topic, the team members may come from multi-disciplines. In this environment, alignment on the research scope and direction becomes an essential part of the research process. The alignment process can enrich the content of research through the exchange of different ideas and perspectives within a team. However, conflicts may exist during the alignment process, and some conflicts may become destructive hindering productive alignment processes.

	Alignment	Balance between rigor and practicality	Evolving nature
What	Member alignment on research scope and direction	Balance between academic rigor and industry practical relevance	Changing nature of research scope, plan, and methodology
Why	Team members with various backgrounds and perspectives (heterogeneous group)	To satisfy the needs of both industry & academia	Team members consisting of academics and industry members from various experience and backgrounds (heterogeneous group)
Key benefit	Richness of research content	Potential for increased credibility and implementability	Providing an opportunity for innovative ideas/methods
Key challenge	Maintaining constructive conflicts and avoiding destructive conflicts	- Time and cost constraints - Lack of understanding between academic and industry members	"Execute the plan" mode of industry members
Need	Knowing when to explore various perspectives and when to focus	Collaboration based on mutual understanding	Collaborative research development

Table 8-6: Process Attributes – Research Methodology

A balance between academic rigor and industry practicality was found as another key process attribute in regard to research methodology. Academia-industry collaborative research is applied science research to develop a solution implementable by industry. However, it does not exclude fundamental knowledge and research approaches. As noted earlier, Mode 2 knowledge production crosses the boundary between fundamental

science and applied science absorbing knowledge produced by both sides seeking the best solution applicable to a given research problem. A bias towards one side may not satisfy the purpose of conducting collaborative academia-industry research. One potential benefit of this balance is the increased credibility of research results, which may increase the possibility of implementation.

Evolving nature emerged as a key process attribute during the cross-case analysis. This evolving nature refers to this research scope, plan, and methodology change during the course of the research. Mode 2 knowledge production exhibits transdisciplinarity and heterogeneity. Here, the research participants to produce knowledge across disciplines with the everyday experience of the industry. The industry where these research outcomes will be applied is continuously changing as well. Thus, it is important to acknowledge that the research process may evolve accordingly reflecting those changes as well as incorporating various ideas of team members. This evolving nature may provide a team with an opportunity for introducing breakthrough ideas, new research scope or research methods into the research process. Nevertheless, it may be a challenge for research participants from the construction industry to accept this evolving nature since project managers are accustomed to maintaining an "execute the plan" mode.

8.5.2 Key process attributes – Team Dynamics

As collaborative academia-industry research suggests, the research is established on cooperation and collaboration between academic and industry participants to achieve the research purposes and objectives. Gibbons et al. (1994) noted that industry participants of Mode 2 knowledge production become active contributors of knowledge production since Mode 2 knowledge is to be implemented in their business or industry to solve their problems. This study identified 5 process attributes regarding team dynamics

from collaborative academia-industry research. These 5 attributes are diverse team composition, mixed leadership, participation and commitment, people relationships, and team management. These attributes are associated with transdisciplinarity and heterogeneity and organization diversity of Mode 2 knowledge production. Table 8-7 describes these five attributes.

Diverse team composition was noted as strength from all the 11 cases. The interviewees perceived that one of their strengths was a good mix of team members with various experience, knowledge, and backgrounds. A key benefit of this diverse team composition is that it can provide a favorable environment for a team to explore diverse knowledge, experience and new perspectives of members from various organizations. A potential challenge is to select diverse and competent team members with knowledge relevant to a given research topic so that diversity can actually contribute to the research process.

A collaborative academia-industry team typically has mixed leadership, which means leadership comes from both academia and industry sides. This is a unique characteristic of academia-industry research collaboration since a collaborative academia-industry research team needs academic leadership from the research process perspective as well as industry leadership from knowledge domain perspective. This attribute is enhanced if there is a balance between academic and industry leaders as academic rigor and industry practicality need to be balanced. The dual leadership may bring challenges including setting a clear research responsibility. Since there is dual leadership, one side may abdicate their role and responsibilities to the other. Therefore, it is also essential to clearly establish separate roles and responsibilities between academic and industry leaders to avoid the research process being dependent on one side only.

	Diverse team composition	Mixed leadership	Participation and commitment	Interpersonal relationships	Management of a temporary & heterogeneous team
What	Team consisting of members with different backgrounds, expertise, and experience	Coexistence of academic leadership and industry leadership	Collaborative teamwork based on participation and commitment of team members	Personal relationship and networking within a team	Team management
Why	Team members with various backgrounds and perspectives (heterogeneous group)	"Process and domain" – academic leadership for the research process and industry leadership for knowledge domain	Research incorporating the input from team members	Team members with various backgrounds and perspectives (heterogeneous group)	Voluntary participation
Key benefit	Potential for incorporating diverse knowledge and innovativeness	Shared responsibility between leaders	Addressing actual industry needs	Improved participation	Improved participation
Key challenge	Diversity within the context of a given research topic	Clear point of research responsibility	Potential for domination of the research direction by a small group	Time and cost constraints	Voluntary team
Need	Selection of competent team members	Establishment of leader roles & responsibilities	Balanced contributions of all team members	Relationship building and social activities	Meeting effectiveness

Table 8-7: Process Attributes – Team Dynamics

Participation/commitment was identified as a key attribute in terms of team dynamics. In an academic-industry collaborative research team, particularly in the case of a CII research team, industry team member participate as active contributors rather than in an advisory role. If research participants do not actively contribute, failing to provide input as knowledge domain experts, the research outcome may have less chance of being effectively implemented to solve a targeted problem. One of challenges in regard to participation and commitment is that a team may become dominated by a small group of members who actively participate in research activities.

Interpersonal relationship was identified as an attribute since interpersonal relationship building naturally happens and becomes a foundation of teamwork in an academia-industry collaborative team as it does in other forms of teams. Building a good relationship between team members can promote participation and commitment. However, limited time and cost typical for teams can be challenges. Particularly, when the economic environment is not favorable and companies impose travel restrictions, members tend to participate via phone or web conferencing, which in turn becomes a hindrance to building interpersonal relationships.

Management of a temporary and heterogeneous team was identified as another key attribute for team dynamics. When the interviewees were asked lessons learned from their experience with the cases, many of them mentioned time management, communication, meeting operations, and social activities, which fall into team management. This attribute becomes more apparent for a collaborative academia-industry research team such as a CII research team because industry team members are volunteers, and it requires additional time commitment for them to participate in research activities.

Therefore, it can be a challenge if there are not effective communication channels to encourage voluntary team members to be prepared for the meetings.

8.5.3 Key process attributes – Product Design and Development

Mode 2 knowledge is produced for the purpose of application within industry. Therefore, implementability of research outcomes was identified as the key process attribute related to product design and development. Table 8-8 summarizes this attribute.

	Research outcomes focusing on implementability
What	Producing implementable outcomes
Why	Knowledge production for application
Key benefit	Increased dissemination and implementability
Key challenge	Packaging of research findings for implementation
Need	Products with clear target audience and focusing on users

Table 8-8: Process Attributes – Product Design & Development

If research outcomes are not usable or applicable to the industry, the research is likely to lose an opportunity to bring its impact on the industry no matter how academically rigorous and valuable the outcomes are. When the interviewees were asked success factors for collaborative academia-industry research from their perspective, implementability or applicability was mentioned most as discussed in the section 8.3. It is also well connected with Mode 2 knowledge production which purports the application to the real world (Gibbons et al., 1994). One challenge regarding this attribute is to package

research findings within the time and cost allotted into a form that can be used as an industry practice.

8.5.4 Key process attributes and success factors

Table 8-9 presents key factors associated with each of the process attributes discussed in the previous sections. Some recommended practices were also proposed for each attribute, in an attempt to provide guidance for research participants in applying to an actual research process. These recommendations were derived from the interviews, and, henceforth, they were either actually used by the cases or recommended practices by the interviewees.

Case subunits	Key Process Attributes	Key Success Factors	Recommended Practices
Research Methodology	Alignment	• Facilitation skills of team leaders • Constructive alignment processes • Mutual respect and willingness to listen • Continuous alignment effort • Member personalities	• Prior education and/or training of team leaders • Revisiting the mission statement every meeting
	Balance between academic rigor and industry practicality	• Research design appropriate for a given research question • Research credibility and validity • Analysis and outcomes making sense to the industry • Mutual understanding between academics and industry participants	• Careful planning of data collection • Utilization of multiple data collection methods • Collecting sufficient and quality data • Securing access to data • Keeping transparency and continuous communications of interim research outcomes with industry members • Using a scientific approach – putting academic rigor behind a tool or model developed for implementation • Consider mutual benefits of academia and industry • Orientation sessions for industry members about research
	Evolving nature	• Flexibility • Openness	

Table 8-9: The Attributes and Key Success Factors in Academia-Industry Collaborative Research

Case subunits	Key Process Attributes	Key Success Factors	Recommended Practices
Team Dynamics	Diverse team composition	• Level of skills, expertise, experience and knowledge of members • Diversity within the context of a given research topic	• Careful selection of research participants especially in the case of chairs
	Mixed leadership	• Leadership balance between academic and industry leaders • Clear establishment of leader roles and responsibilities • Compatibility and openness between leaders	• Prior education and/or training of team leaders • Co-preparation of meeting agenda • Regular leadership communications

Table 8-9, continued.

Case subunits	Key Process Attributes	Key Success Factors	Recommended Practices
Team Dynamics (cont'd)	Participation and commitment	• Open and attentive leadership promoting and encouraging participation and contribution of all members • Interest and passion of members in a given research topic • Shared value/benefit/vision of research • Meeting effectiveness • Learning opportunity • People relationship • Company support • Support from a funding agency	• Setting expectations by chairs • Meeting facilitation to make everybody's voice heard and valued and to avoid any person dominating the discussions • Use of the subgroup approach • Personal or group assignment from start (e.g., background studies, reading relevant CII materials, collect company practices) • Committed and passionate core group • Selection of members with interest and dedication to the topic • Constructive alignment process • Meeting preparation and communication of meeting agenda with members in advance • Social activities (cultural events, team dinner) • Support from the team member companies to participate in meetings and research activities

Table 8-9, continued.

Case subunits	Key Process Attributes	Key Success Factors	Recommended Practices
Team Dynamics (cont'd)	Interpersonal relationship	• Mutual understanding and respect • Open-minded attitude • Team-focus/teambuilding /networking	• Social activities • Planning face to face meetings in different locations and preparing some activities related to location (e.g., tour by hosting company, etc.)
	Management of a temporary and heterogeneous team	• Continuous and persistent communication • Effective and efficient meeting planning and operation	• Utilization of online collaboration workspace for communication and data repository • Period webinars(e.g., monthly) for progress update • Preparation of chairs and PIs to make member feel time well spent • Keeping meeting minutes • Providing learning opportunities
Product Design and Development	Research outcomes focusing on implementability	• Usability and applicability • Relevance and practicality • Value and quality • Comprehensiveness • Innovativeness	• Clearly defined target audience • Keeping users in mind • Meeting research objectives • Including new ideas and/or different perspectives • Looking at other industries as well as path forward

Table 8-9, continued.

8.6 SUMMARY

This chapter presented the process and findings of the second part of the cross-case analysis of the 11 cases. This included an investigation of additional information provided by the interviewees in terms of lesson learned and their perspectives on the success of collaborative academia-industry research. The content analysis method was used to identify meaningful themes and concepts, and those identified themes and concepts were categorized into the three subunits of analysis (i.e., research methodology, team dynamics, and product design and development) and proposition categories. By counting the number of comments appearing in each theme and category, the relative importance between the themes perceived by the interviewees was determined. The findings were discussed in comparison with the findings in the previous chapter as well as the literature review.

Based on the consolidated findings of the two parts of the cross-case analysis, 9 key process attributes and a number of success factors were identified. Useful practices were also recommended to improve the factors for each attribute. The next chapter will summarize this study and provide conclusions and recommendations.

Chapter 9: Conclusions and Recommendations

This chapter provides a summary of the findings and conclusions of this study with a review of the research objectives and questions. In addition, limitations and contributions will be discussed followed by suggestions and recommendations for future research.

9.1 Review of Research Objectives and research Questions

The primary purpose of this study was to improve the process of the collaborative academia-industry research in construction engineering and project management by identifying key attributes and success factors that differentiate successful and less than successful research. The four research objectives to achieve this primary purpose included:

1) To define the success of construction industry project management research from both the industry and academic perspectives
2) To identify and investigate collaborative academia-industry research efforts that have been acknowledged as successful and less than successful by both industry and academia
3) To identify key research process attributes and success factors leading to the research success
4) To develop recommendations for more effective and high value research

The research questions to achieve the above objectives were developed as below:

1) What is success of collaborative academia-industry research in construction industry project management and what are the success criteria?
2) What are the success indicators of collaborative academia-industry research?
3) What are the key process attributes and key success factors of collaborative academia-industry research?

The following subsections will discuss how this study achieved each of the four research objectives.

9.1.1 Definition of success of collaborative academia-industry research

To identify key process attributes and factors of successful collaborative academia-industry research process, it is important to define research success. Since there is a lack of common definition in previous studies, this study established as the first objective to define success of collaborative academia-industry research. In Chapter 2, the definition of collaborative academia-industry research success was proposed based on the literature review as presented below.

> *'The success of collaborative academia-industry research is defined as producing research outcomes with a significant impact on participating groups or organizations delivering academic rigor and industry practicality through a scientific research methodology and collaborative team approach.'*

The success criteria were identified from the literature review. The core criterion is impact of the research outcomes, which can be further divided into impact on the industry and the academia in short-term and long-term timeframes. The short-term

industry impact includes initial dissemination and research progress performance, and the long-term industry impact includes dissemination, implementability, and value of the research outcomes. The long-term academic impact includes dissemination and value from the perspective of academia.

The success definition and criteria developed were then combined with the CII research process model on which the conceptual research framework was developed. Within the context of the conceptual research framework, 11 research propositions were developed based on the literature review on key success factors in academia-collaborative research.

9.1.2 Identification of successful and less than successful collaborative academia-industry research studies

Chapter 5 discussed the data collection process to identify the cases for in-depth case studies. The case selection criteria were implementation, value, and dissemination, which were identified as success criteria in Chapter 3. Data collection methods were carefully selected as success indicators to evaluate the success of the CII research efforts. These methods used for case identification and selection include survey, product dissemination data, relevant CII documents and archival records, and input from the CII Research Committee.

From over 150 CII research efforts, a total of 11 research efforts were identified for the case studies. These 11 cases were purposely selected as extreme cases to learn which aspects differentiate successful and less than successful research. The 11 cases selected were categorized as Distinguished, Atypical, Established, and Special.

9.1.3 Identification of key research process attributes and success factors

The research method of this study was multi-case studies. The primary data collection method was individual interviews with the research participants of the 11 cases, although other relevant data were also collected and analyzed for data triangulation and supplementation. A cross-case analysis of the 11 cases was conducted to validate the research propositions and to discover emerging findings.

The research propositions were examined to determine whether each proposition was supported or not. Of the 11 propositions, 7 were supported while the other 4 propositions were partially supported. The case data were fully investigated and emerging themes and concepts were identified. Through the various analyses, the definition of collaborative academia-industry research, and its success factors were identified, and lessons learned provided by the interviewees were analyzed. Table 9-1 summarizes the key differences between the Atypical cases and the others assessed from the cross-case analyses of the 11 cases.

9.1.4 Development of recommendations

The findings of the cross-case analyses were consolidated into a list of key process attributes and success factors. A total of 9 attributes of collaborative academia-industry research were identified in research methodology, team dynamics, and product design and development. A set of key success factors expected to enhance these 9 attributes and the practices associated with each success factor were also presented as practical recommendations to improve the collaborative academia-industry research process. The recommendations will be discussed in detail in the next section.

Category Level 1 (case subunits)	Category Level 2	Established / Distinguished / Special	Atypical
Research Methodology	Research scoping		• Had difficulty in clarifying and interpreting the research topic statement
	Data collection methods	• Used multiple data collection methods	• Depended on a single data collection method
Team Dynamics	Leadership	• Had strong leadership	• Had PI leadership issues • Had less strong leadership from industry chairs
	Participation and commitment	• Had a committed core group • Had strong participation and relatively even contributions of industry members	• Participation deteriorated
	Team management	• Had competent graduate students	

Table 9-1: Key Findings by Case Category

9.2 RECOMMENDATIONS FOR SUCCESSFUL COLLABORATIVE ACADEMIA-INDUSTRY RESEARCH

Key recommendations as a conclusion of this study are summarized in Table 9-2. These recommendations are categorized into the three case subunits, which are research methodology, team dynamics, and product design and development. These recommendations were considered as having a possibility to improve the research process of academia-industry research collaboration if implemented.

Category	Recommendations
Research Methodology	• Maintain constructive conflicts and avoid destructive conflicts during alignment processes • Use multiple data collection methods and/or multiple data sources • Keep academic rigor in the research approach and communicate its importance with industry members • Be aware of and accept the evolving nature of the research process • Maintain flexibility and openness
Team Dynamics	• Explore various perspectives and ideas from diverse team members while keeping the research direction on track • Clearly establish leadership roles and responsibilities between academic and industry leaders • Establish regular leadership communications • Enhance the role of a core group as well as encourage contributions of other members • Utilize a subgroup approach to promote participation and engagement of team members • Build interpersonal relationships • Manage meetings effectively
Product Design and Development	• Produce implementation guidance • Clearly define target audience in developing implementation guidance

Table 9-2: Key Recommendations

9.3 CONTRIBUTIONS

The primary contribution of this study was to identify the key process attributes and success factors for a collaborative academia-industry research effort. Research collaboration between industry and the academia is likely to expand as advanced knowledge is required to address the complexity of today's projects. This research

contributes to the body of knowledge by providing important considerations for the participants of such collaborative research.

Major contributions of this study in terms of the academic perspective are presented as below.

1) This study defined the success and the success criteria of collaborative academia-industry research, and developed the conceptual framework for the collaborative academia-industry research process.
2) This study suggested an approach to assess research success using a set of indicators associated with the success criteria.
3) This study explored the process of successful and less than successful collaborative research team efforts through multiple-case studies of the 11 cases providing an in-depth picture of such research process from the aspects of research methodology, team dynamics, and product design and development.
4) This study presented the key findings that emerged from the comprehensive cross-case analysis. These findings were compared with the existing key factors suggested by the extant literature and consistencies and discrepancies were identified.

From an industry perspective, major contributions of this study are presented as below.

1) This study identified the research practices useful for industry research participants of collaborative academia-industry research.
2) This study provided lessons learned of the interviewees from their actual research experience.

3) This study can be utilized as guidance to participants who join a collaborative academia-industry research team for the first time.

9.4 LIMITATIONS

The limitations of this study relate to scope and data collection. First, since the scope of this study is limited to the research team process of CII type collaborative academia-industry research efforts, the findings of this study may not be applicable to other forms of academia-industry research collaboration. Since CII has been sponsoring research efforts for more than 30 years, its process is well developed. CII provides numerous resources to support the research efforts as do the CII member companies. Therefore, the industry participants of CII research efforts may have experienced a more favorable research environment for success than others on non-CII research efforts. This implies that research participants on non-CII research efforts may perceive different factors; for example, company support, funding, or administrative and managerial, as being more critical than the participants of CII research.

A second limitation is that this study assessed the implementability and value of CII Knowledge Structure Focus Areas rather than individual research efforts. Since CII has sponsored over 150 research efforts, it was considered unpractical to assess all 150 individual research efforts. Therefore, this study assessed the impact of 59 Focus Areas where individual CII research efforts are categorized and managed. This approach may raise an accuracy question in determining the success of individual research efforts.

Another point that should be noted is the limitation of data for old research efforts. Even though the three Established cases were identified as its research success has been established for over a long period of time, it was difficult to collect some data since these

research efforts were conducted between 10 to 25 years ago. It was also challenging to contact interviewees for these cases, and, as a result, only one industry members was interviewed from 5 interviewees of the three Established cases.

9.5 RECOMMENDATIONS FOR FUTURE RESEARCH

The research collaboration between academia-industry in construction engineering and project management is a relatively new area compared with the research and development efforts in other industries such as pharmaceutical or information technology industries. Therefore, there still exist numerous areas to be explored to improve such research collaboration in construction engineering and project management. This study suggests four potential areas for future studies.

1) Investigate other important factors outside the research process
   - Topic identification and selection
   - Formation of a research team and member selection
   - Dissemination and implementation efforts

Although the scope of this study focused on the research team process from team formation to its close out, the findings indicated that other factors beyond this scope also have impact on the research team process. Such factors include identification of proper research topics, selection of competent team members, and effective dissemination and implementation of research outcomes. Particularly, selection of the right research topics for a collaborative research team was perceived as reasonably important to research success from the analyses in this study. Moreover, research topics for pure academic research and for collaborative academia-industry research have inherently different nature. Therefore, it is likely that the research topic identification and selection process

for academia for collaborative academia-industry research is different from that of pure academic research. In addition, research topics have influences on team member selection and research methodology as well as dissemination and implementation. Thus, it is recommended to investigate an effective selection process for topics that will positively influence the research performance.

2) Explore assessment approaches for interim research performance

This study identified dissemination of research outcomes and research progress performance as short-term success criteria. From the perspective of a research funding agency, it is necessary to develop methods for appropriate and timely assessment of research team performance to increase the possibility of guiding it to a successful research effort. Thus, this opens a new avenue for future research.

Particularly, this study did not use the short-term success criteria from an academic perspective assuming that it takes time for academia to review, absorb, and assess outcomes of certain research studies. However, there can be various short-term success criteria such as short-term bibliometrics including conference publications or presentations. In addition, for the long-term success criteria from the academia perspective, use of research products in the classroom needs to be evaluated for its appropriateness as a success criterion.

3) Assessment of research impact

This study assessed the impact of the research outcomes in terms of dissemination, implementability, and value to industry and academia using the long-term and short-term success indicators including product downloads and sales data, journal citations, various user surveys, and expert group nominations. There is a need to explore more measures to assess dissemination, implementability, and value of research outcomes depending on the

timeframes, industry, and academia sides. The use of a single measure compared with multiple measures also needs to be evaluated for its accuracy and efficiency.

4) Examine other collaborative academia-industry research processes outside CII

Data collection for this study was limited to the CII research efforts. The investigation of the CII research efforts, an exemplary model for academia-industry research collaboration, provided in-depth understanding of extensive and formal collaborative research. Nevertheless, there certainly exist other types of research collaboration including university-company research collaboration, research efforts with smaller numbers of team members, and research efforts where industry practitioners play a consulting or advisory role. Thus, expanding the findings of this study to these various forms of collaborative research and conducting validation of the findings (i.e., the findings of study are still valid to other forms) are recommended for future research.

5) Validate the findings of this study

Since this study was based on the analysis of CII research efforts, it opens an opportunity for future research in terms of validation. First, it is recommended to assess the long-term impact of the 8 recent cases after a certain implementation period passes and to validate that the short-term success is closely connected with the long term success. Second, it is recommended that the findings of this study can be applied to future CII research efforts, and any differences in the research process can be monitored. This validation effort may provide an opportunity to evaluate the relative weights or importance between the key attributes and factors identified in this study and further refine the findings of this research.

Appendices

Appendix A: CII Knowledge Structure Focus Areas and CII Research Teams

No	Knowledge Structure Focus Area	Description	Research Team	
1.01	Front End Planning	The essential process of developing sufficient strategic information with which owners can address risk and make decisions to commit resources in order to maximize the potential for a successful project.	39	Pre-Project Planning
			113	Front End Planning
			155	PDRI for General Building Projects
			213	Support for Pre-Project Planning
			221	Information Flow to Support Pre-Project Planning
			242	Front End Planning for Renovation/Revamp Projects
			268	Project Definition Rating Index Tool for Infrastructure Projects
1.02	Alignment	The condition where appropriate project participants are working within acceptable tolerances to develop and meet a uniformly defined and understood set of project objectives.	12	Project Organization
			113	Front End Planning
1.03	Modularization/ Preassembly	Prefabrication, preassembly, modularization, and offsite fabrication (PPMOF). The construction methods which offer potential benefits to owners through reducing cost, schedule, and risk and improving productivity.	171	Modularization and Offsite Assembly
			29	Modularization
			283	Modularization
1.04	Construction Input in Front End Planning	The process of optimizing construction input during front end planning by identifying practices to bring construction expertise and resources needed.	241	Optimizing the Value of Construction in Front End Planning
			131	Improving Early Estimates

No	Knowledge Structure Focus Area	Description	Research Team	
2.01	Constructability	The effective and timely integration of construction knowledge into the conceptual planning, design, construction, and field operations of a project to achieve the overall project objectives in the best possible time and accuracy at the most cost-effective levels.	3	Constructability
			34	Constructability Implementation
2.02	Design Effectiveness	A process of evaluating and enhancing design effectiveness to achieve targeted project goals and value objectives.	8	Design
			9	Technology
			50	ADA Impacts
			153	Effects of Field Rework
			163	Evaluating On-Site Design
			233	Planning for, Facilitating, and Evaluating Design Effectiveness
			245	Optimizing Engineering Value in Projects
2.03	Piping Design	Tools to improve the efficiency of the piping function to bring benefits to companies.	47	Piping Function
2.05	Cost Effective Engineering	An assessment study on the innovative or non-traditional practices used by NUCOR.	112	Cost Effective Engineering
2.06	Designing for Maintainability	A guide to a comprehensive approach to establishing or improving design for maintainability process in order to minimize life cycle costs of capital facilities.	142	Design for Maintainability
2.07	Design for Fast Track	The study which identifies best practices that have an impact on the performance of the design phase in fast track projects.	222	Best Practices for Design in Fast-Track Projects

Appendix A, continued.

No	Knowledge Structure Focus Area	Description	Research Team	
3.01	Materials Management	An integrated process for planning and controlling all necessary efforts to make certain that the quality and quantity of materials and equipment are appropriately specified in a timely manner, are obtained at a reasonable cost, and are available when needed.	7	Materials Management
			257	Global Procurement & Materials Management Best Practice Refresh
3.02	Supplier Relationships	An innovative process to reform the owner/contractor/ supplier relationships in engineer-procure-construct (EPC) project in order to improve cost/time/quality performance.	130	Reforming Supplier Relationships
			172	Supply Chain Management Concepts
			264	Product Integrity Concerns in Low-Cost Sourcing Countries
4.02	Lean Construction	A guidance to implementing lean principles in the construction industry	191	Lean Principles in Construction
			234	Implementation Road Map of Lean Construction at Project Level
			265	How Do We Use Industrial Engineering/ Manufacturing Techniques for Enhancing Construction Project Performance?
4.03	Assembly and Manufacturing Techniques	Evaluates applicability of shipbuilding techniques and process to the construction industry.	232	Examination of the Shipbuilding Industry
			255	Adaptation of Shipbuilding Production Systems to Construction
			271	Innovative Project Delivery Processes - Is There a Better Way?
5.01	Planning for Start-up	Planning the transitional phase between plant construction completion and commercial operations, which encompasses all activities including systems turnover, check-out of systems, commissioning of systems, introduction of feed stocks, and performance testing.	121	Planning for Startup

Appendix A, continued.

No	Knowledge Structure Focus Area	Description	Research Team	
6.01	Employee Incentives	A guide to select and implement appropriate employee incentive plans based on project type and objectives.	140	Project Incentives
6.02	Management of Education and Training	Provides approaches and tools to facilitate effective and efficient training and education in the construction industry.	14	Education and Training
			40	Continuing Supervisory Education
			157	Technology-Assisted Learning
			201	Achieving Learning Organizations in the EPC Industry
			231	Construction Industry Craft Training
			292	Knowledge Transfer from the Near-Retirement Generation to the Next Generation
6.03	Attract and Maintain Skilled Workers	Provides strategies and recommendations to attract and maintain workforce to solve shortage of skilled craft workers in the construction industry.	28	Construction Work Force
			135	Attract/Maintain Skilled Work Force
			182	Addressing Shortage of Skilled Craft Workers in the U.S.
			200	Attract, Recruit, and Retain Construction Leaders
			253	Estimating as a Competency in Capital Projects
			281	Project Management Skills of the Future
6.04	Craft Productivity Practices	Provides various practices, strategies and tools to improve construction worker productivity, which include productivity measurements, Voice of the Craft Worker (VOW), the buffer strategy and production planning strategy, and activity analysis.	2	Productivity Measurements
			11	Organizational Culture in Engineering and Construction Organizations
			33	Overtime
			143	Craft Productivity Improvement
			215	Workforce View of Construction Productivity
			252	Craft Productivity Research

Appendix A, continued.

No	Knowledge Structure Focus Area	Description	Research Team	
6.05	Multiskilling	Investigates the current status and potential benefits of multiskilling strategies in the construction industry.	137	Multi-Skilled Craft Capabilities
6.06	Engineering Productivity Measurement	Process, model, and techniques to measure engineering productivity	156	Engineering Productivity Measurements
			192	Engineering Productivity Measures II
7.01	Team Building	A project-focused process that builds and develops shared goals, interdependence, trust and commitment, and accountability among team members and that seeks to improve team members' problem-solving skills.	37	Project Team Building
			105	Project Team Communications
7.02	Partnering	A long-term commitment between two or more organizations as in an alliance or it may be applied to a shorter period of time such as the duration of a project. The purpose of partnering is to achieve specific business objectives by maximizing the effectiveness of each participant's resources.	17	Partnering
			24	Contracting Phase II
			102	Partnering II
7.03	Organizational Work Structure	An owner/contractor work structure process model and alignment framework to manage the participant relationships in order to deliver successful capital projects.	35	Owner Engineering Organization
			103	Project Organization II
			111	Owner/Contractor Work Structure
			204	Owners' Role in Project Success

Appendix A, continued.

No	Knowledge Structure Focus Area	Description	Research Team	
7.04	Leader Selection	A set of implementation strategies to implement right leadership for high performance project teams.	134	High Performance Work Teams
7.05	Project Teams	Provides direction for implementing and managing a virtual team in a global project management environment.	170	Making Virtual Teams Work
			211	Effective Use of the Global Engineering Workforce
7.06	Jobsite Organization	Identifies and describes industry norms for jobsite organizational functions and staffing levels for different types of projects under different circumstances.	261	Optimizing Jobsite Organization
8.01	Quality Management	Quality management incorporates all activities conducted to improve the efficiency, contract compliance and cost effectiveness of design, engineering, procurement, QA/QC, construction, and startup elements of construction projects.	10	Quality Management
			21	Project Team Risk/Reward Allocation
			31	Total Quality Management
			36	Quality Performance Measurement
			203	Do It Right the First Time
			254	Quality Management Best Practice Refresh
8.02	Implementation of CII Research	The comprehensive and effective use of proven CII products by member organizations as outlined in the CII Implementation Model.	1	CICE Impact Evaluation
			42	Barriers to Implementation
			166	Barriers to Implementation Update (Implementation Strategy Committee)
			246	The Implementation Planning Model
8.03	Lessons Learned	A critical element in the management of institutional knowledge, effective lessons learned program will facilitate the continuous improvement of processes and procedures and provide a direct advantage in an increasingly competitive industry.	123	Modeling Lessons Learned
			230	Effective Management Practices and Technologies for Lessons Learned Programs

Appendix A, continued.

No	Knowledge Structure Focus Area	Description	Research Team	
8.04	Small Projects Execution	An implementation guide to successfully execute and manage smaller projects.	161	Executing Small Capital Projects
8.06	Work Process Simulation	Evaluates the current use of electronic simulation in construction and addresses the benefits, barriers and limitations of its implementation.	154	Electronic Simulation in Construction
8.07	Innovation and Technology Implementation	Guidance to improve the construction industry by implementing new technologies and process innovation.	173	Update Construction Technology Needs
			243	Enhancing & Expanding Innovation in the Engineering & Construction Industry
8.08	Value Management	Processes to manage and align various project value objectives and value interests to achieve project success.	184	Value Management Toolkit
			266	Identify and Define Owner Value Interests and Align the E&C Response
8.09	Change Management	The process of incorporating a balanced change culture of recognition, planning, and evaluation of project changes in an organization to effectively manage project changes.	27	Change Order Impacts
			43	Project Change Management
			158	Cumulative Change Order Impacts
9.01	Cost & Schedule Control	Provides various techniques and tools to control and reduce cost and schedule in construction projects.	6	Cost/Schedule Controls
			41	Schedule Reduction
			107	Predictive Tools
			124	Re-Engineering the EPC Process
			185	Cost Effectiveness of Innovative Crew Scheduling
			193	Radical Reduction in Project Cycle Time
			214	Trade-Off Between Cost and Schedule
			282	Managing Indirect Costs
			291	Improving the Accuracy of Project Outcome Predictions

Appendix A, continued.

No	Knowledge Structure Focus Area	Description	Research Team	
9.02	Work Packaging	Explains many tools available to enable the application of work packaging to all phases of a construction project.	6	Cost/Schedule Controls
			272	Enhanced Work Packaging: Design through WorkFace Execution
9.03	Project Health Assessment	A management process to evaluate and identify future project risk in a proactive manner.	220	Leading Indicators to Project Outcome
9.04	Global Project Control and Management Systems	Guidance to improve PCMS implementation processes and procedures.	244	Global Project Control and Management Systems
10.01	Disputes Prevention & Resolution	Techniques that include the use of a Disputes Review Board as an alternate dispute resolution process for addressing disputes in their early stages before affecting the progress of the work, creating adversarial positions, and leading to litigation.	23	Dispute Prevention and Resolution
10.02	Project Delivery and Contract Strategies	Process model to implement effective project delivery and contract strategy systems in accordance with various project conditions and objectives.	5	Contracts
			133	Design/Build
			165	Project Delivery and Contract Strategy
			205	Commodity vs. Value Added Contractor Services
			260	Reimbursable Contracts
10.03	Use of Project Incentives	Addresses innovative contractor compensation strategies.	114	Contractor Compensation
10.04	Risk Management Basics and Insurance	Identifies the current risk sharing practices among parties to construction contracts and presents a new approach to optimizing risk treatment.	19	Insurance
10.05	Equitable Risk Allocation	Introduces the Two-Party Risk Assessment and Allocation Model.	210	Contracting to Appropriately Allocate Risk

Appendix A, continued.

No	Knowledge Structure Focus Area	Description	Research Team	
10.06	Project Risk Assessment	Identifies risks related to capital project and provides a tool to facilitate risk assessment.	181	Risk Analysis for International Projects
			280	Methods for Dealing with Uncertainty - Applying Probabilistic Controls in Construction
11.01	Zero Accidents Techniques	Include the site-specific safety programs and implementation, auditing, and incentive efforts to create a project environment and a level of training that embraces the mindset that all accidents are preventable and that zero accidents is an obtainable goal.	13	Safety
			32	Zero Accidents
			160	Making Zero Accidents a Reality
			190	Owners' Role in Construction Safety
			216	Target Safety: Programs Focused on Preventing Specific Injuries
			284	Leading Indicators for Safety
			293	Strategies for HSE Hazard Recognition
11.02	Environmental Remediation Management	Provides a proactive management process for contaminated site remediation projects. Identifies key management issues and actions that should be taken along each step in the process.	48	Environmental Remediation Technology
11.03	Design for Safety	A process of identifying safety hazards and design suggestions to improve worker safety in construction.	101	Design for Safety
11.04	Managing Workers' Compensation	Provides recommendations to reduce the costs associated with workers' compensation insurance claims.	45	Workers' Compensation Insurance
11.06	Sustainability	A guide to implement sustainability in construction.	250	Sustainable Design and Construction
11.07	Safety Technologies	Evaluates the applicability and performance of remote sensing technology in improving construction safety.	269	Real-time Pro-Active Safety in Construction

Appendix A, continued.

No	Knowledge Structure Focus Area	Description	Research Team	
11.08	Safety Culture	Identifies the relationship between leader behavior and safety performance.	256	Project Site Leadership Role in Improving Construction Safety
12.01	Automated Identification	Evaluates the potential benefits of using radio frequency identification tagging (RFID) in construction.	151	Radio Frequency Tagging
12.02	Electronic Commerce	Investigates how companies can apply e-commerce successfully to be competitive.	180	e-Commerce Applications for Construction
12.03	Computer-aided Design/Drafting	Provides recommendations on present and future uses of 3D CAD modeling in construction	25	Computer Integrated Design and Construction
			106	3D/CAD Link
			152	3D CADD in FIAPP
12.04	Information Integration	Provides a process and a tool to aid efforts in corporate planning, presentation, and development of specific information management and integration.	20	Electronic Data Management
			125	Information Management Impacts
			258	Information Integration to Improve Capital Project Performance
12.05	Wireless Technology	Assesses the applicability of wireless communication technology to the construction industry.	136	Jobsite Wireless Computing
12.06	Automation and Robotics	Identifies design practices that facilitate the implementation of automated technologies and addresses barriers.	16	Advanced Technological Systems
			183	Design Practices to Facilitate Construction Automation
12.07	Leveraging Technology to Improve Construction Productivity	A model to assess the potential of technology to improve construction productivity.	15	Technology Survey
			46	Technology Strategy
			240	Leveraging Technology to Improve Construction Productivity
12.08	Nanotechnology Applications	Addresses possible applications of nanotechnology in construction and assesses benefits, barriers and impacts of nanotechnology implementation.	251	Nanotechnology and its Impact on Construction

Appendix A, continued.

No	Knowledge Structure Focus Area	Description	Research Team	
12.09	Building Information Modeling	Provides a structured four-step procedure for creating and implementing a BIM Project Execution Plan.		
13.01	International Standards	Provides overview of international standards, the structure of the international standards-setting community, and the influence of U.S. construction industry.	49	International Standards
13.02	Global Construction Industry	Identifies needs, key drivers and critical success factors of true globalization for engineering and construction organizations.	30	International Construction
			263	Globalization
			294	Deploying Best Practices in Developing Countries
14.01	Project Security	Provides security-related best practices in delivery of capital facility projects for the heavy industrial sector.		

Appendix A, continued.

Appendix B: Quality CII Research – Criteria and Characteristics

1. Well-structured and addresses a valid industry concern.

a) High-value, high-impact topic.
b) Clear and concise statement of topic in the RTS.
c) Very precise statement of the Essential Question (or Essential Assignment).
d) Documentation of the topic as a significant industry concern in respected publications.
e) Board of Advisor members are vocal advocates of the research topic.
f) Something new or something that needs to be updated due to industry changes.
g) Industry improvement or advancement.
h) Excites the industry and the academics.

2. Competently done in the CII mold.

a) The RT meets regularly, keeps minutes and maintains a forward momentum. It does not backtrack or lose its way.
b) The RT membership is relatively stable and committed to successfully undertaking a joint venture between industry and academia.
c) The team pursues clear and consistent objectives, not merely ill-defined preferences.
d) In the kick-off meeting, a high bar is set for the RT and a schedule-driven feedback loop is established with the RC.
e) Encourage "breakthrough thinking", discourage mediocrity.
f) Participation is constant; meetings are not affected by random participation or by biased, un-informed, and even uninterested attendees.
g) The academic team members possess and deliver the necessary quantitative and analytical research expertise (Process). The industry team members respect, understand, and appreciate this expertise and support the academics in achieving excellence.
h) The industry team members possess and deliver the necessary domain expertise, influence, and access to resources to support the research. (Domain) The academics respect, understand, and appreciate this domain expertise and does not try to unduly influence this with preconceptions.
i) The research team understands is committed to the research methodology; all team members know where the team is going and how to get there.

- The methodology follows the **"Problem/Question → Hypothesis → Validation → Implementation Guidance"** process defined in the RFP.

- The methodology is solid, committed to paper, and has the support of the whole team before substantial time and energy are spent on the work. The methodology supports the production of breakthrough work.
- The methodology complies with CII guidance on using surveys for data collection. Data collected in the validation phase must be objective and validated; it should not simply be the result of an opinion survey.
- Creativity is key to collecting objective data that is appropriate to the research topic. Beyond using surveys, teams are encouraged to consider using data collection methods such as interviews, workshops, field samples/case studies, and theoretical models, or combinations of these methods.
- The required quantity and quality of data can be collected given the time and other resources available.
- The methodology is doable within the time and cost constraints.
- The methodology will produce an innovative work product - it is not just a matter of cranking the handle and seeing what comes out.

j) Team members have tapped the breadth of their collective experience and resources to think outside the box and - to the best of their ability - to produce breakthrough work. All believe they are pushing a frontier. Team participation is not a chore, it is an adventure.
k) The entire team participates in planning and outlining the research report, but the time, cost, and quality of the final product is the responsibility of the academic.
l) The entire team participates in planning and outlining the research summary but the industry chairs and the industry team members have full responsibility for the delivery and quality of the final product.

3. Performed in the classic research mode.

a) Data used for the work are appropriate and defensible; its provenance is clear, and its statistical parameters and significance are demonstrated.
b) Essential questions are translated into a researchable format, without loss of the essence or impact of the original statement.
c) Objectives are cast in the hypothesize-and-test mode, with multiple explanations having been explored and the most effective explanation selected.
d) Further research needs are clarified by the work - the answer to this question inspires new, clearly stated questions.
e) The work clearly stands on the shoulders of others.

- Relevant background research is outlined. Key work by others may be presented in some detail - supported, refuted, or extended.
- Intellectual property drawn from past work is properly cited.
- CII work and archival sources are heavily used.

f) Conclusions are repeatable. Data and analyses are presented clearly with enough of an analytical framework that other researchers could repeat the study and come to similar conclusions.
g) The team resists the pressure to conclude too much or reach too far.
h) Methods employed are logically related to the essential question.
i) Work has followed a designed and accepted methodology - i.e. the "Problem/Question → Hypothesis → Validation → Implementation Guidance" process.

4. Answers the "essential question."

a) The research product is validated by objective research.
b) The research product is based on fact-based data - not opinions.
c) It provides support for breakthrough thinking.
d) The context and existing information on the topic is conveyed.
e) Various perspectives are considered.
f) Critical assumptions, contrary findings, and alternative interpretations are all discussed.
g) The research product makes cautious conclusions and carefully discusses their implications.
h) It presents results in ways that highlight critical findings.
i) It conveys how the team has responded to the essential question.
j) It provides an answer that can be readily implemented.
k) The research objectives described in the research product are aligned with the essential question.

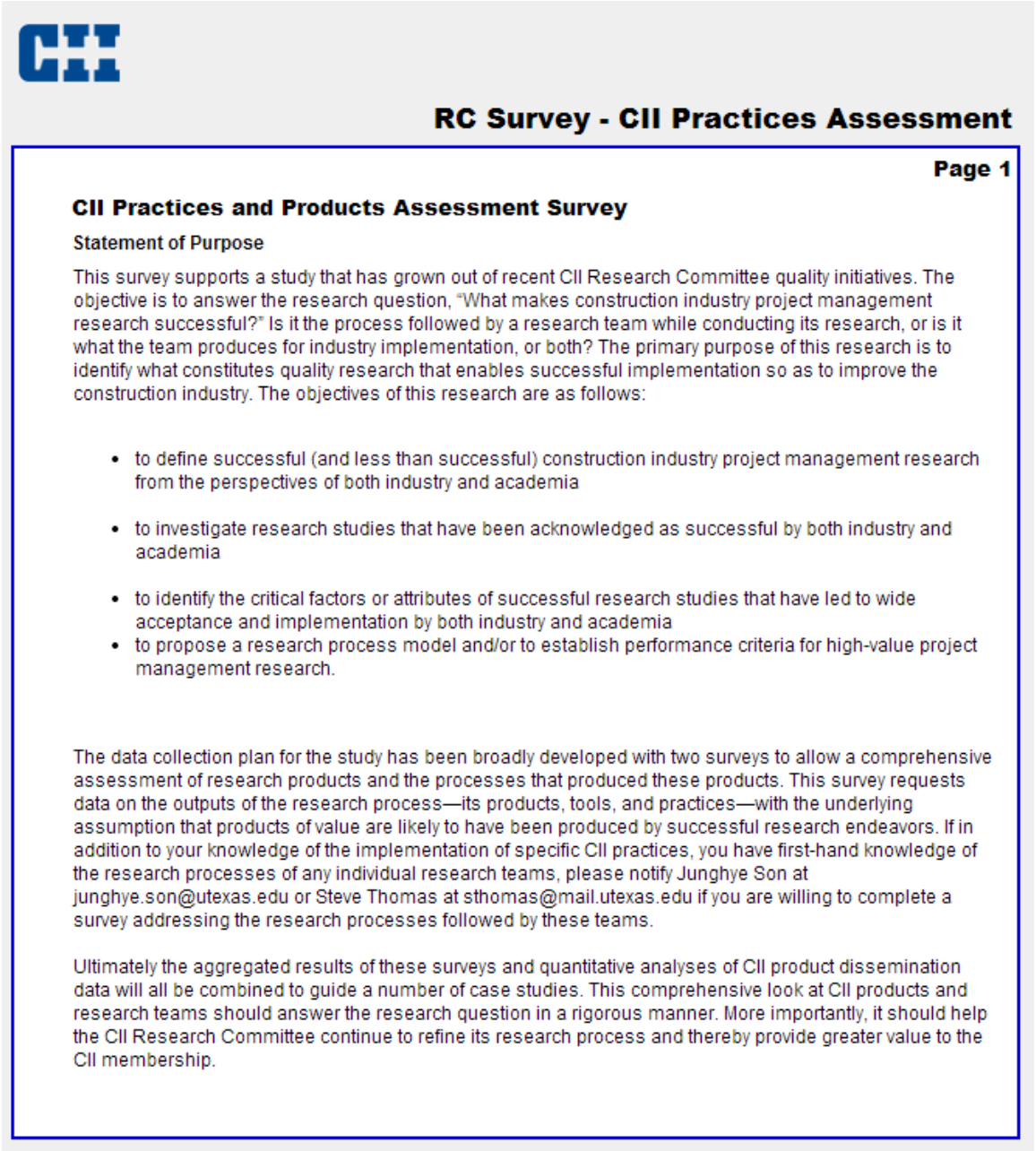
5. Adds value for the CII membership.

a) The research product addresses the need conveyed in the RFP.
b) Tools produced by the team lead to the solution.
c) Data and analysis are presented in a format that can be replicated by other CII members.
d) The research product can be readily implemented.
e) The research product offers a timely solution to or amelioration of a lingering problem.
f) The research team offers a solution or innovation that can improve the industry.
g) Industry adopts and widely uses the research product.

6. Contributes to the storehouse of knowledge.

a) Team completes required documents-producing at a minimum a research summary and a research report-with the understanding that an implementation resource or implementation tool may not be appropriate.
b) Work results in a minimum of one journal article attributed to CII.
c) Work results in a minimum of one conference paper attributed to CII.
d) Work is taught in CII professional development courses.
e) Work is recognized as valuable by other professional development providers or curricula.
f) Graduate or undergraduate courses are modified to include the material.

Appendix C: Industry Assessment Survey



RC Survey - CII Practices Assessment

Page 1

CII Practices and Products Assessment Survey

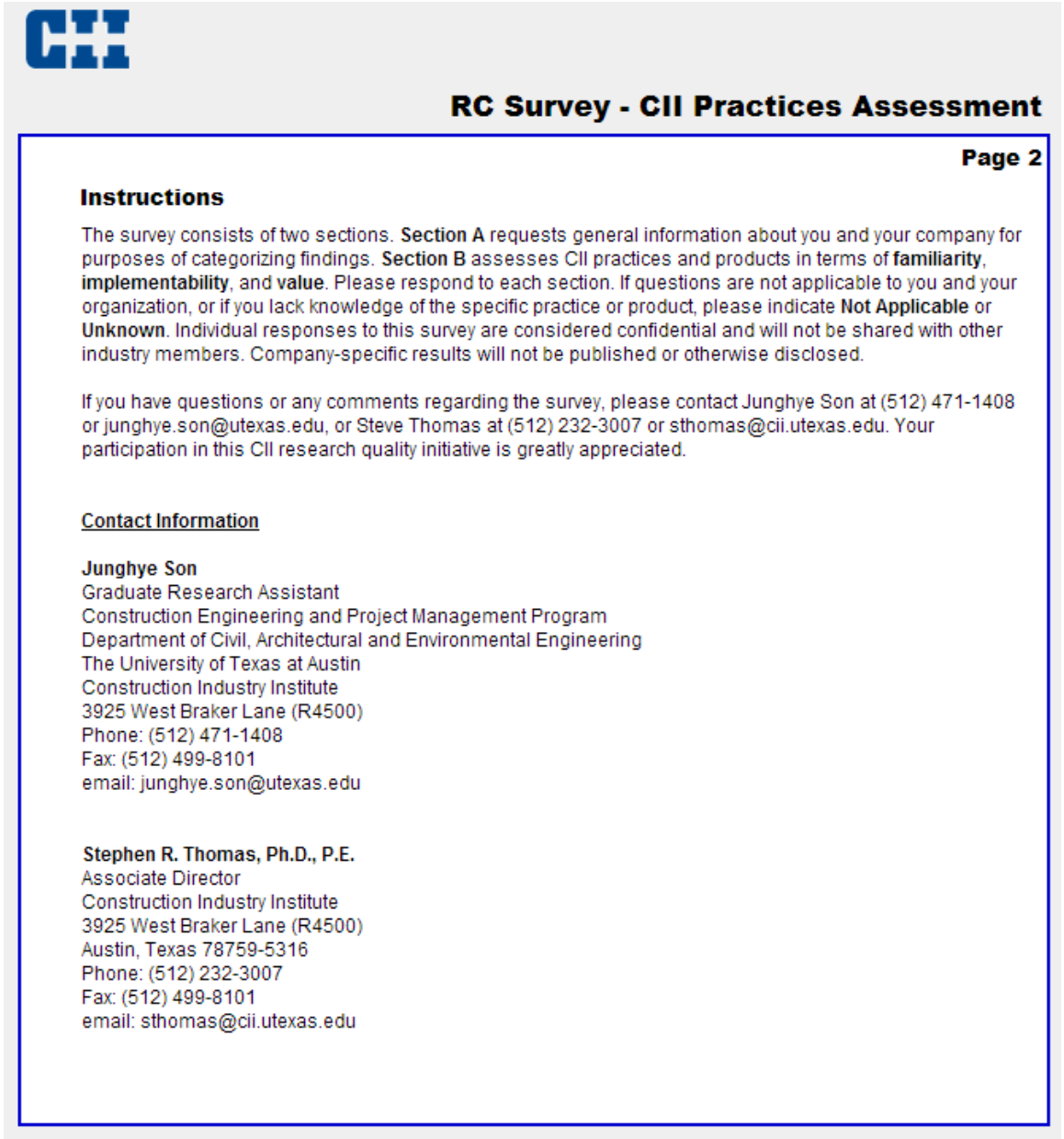
Statement of Purpose

This survey supports a study that has grown out of recent CII Research Committee quality initiatives. The objective is to answer the research question, "What makes construction industry project management research successful?" Is it the process followed by a research team while conducting its research, or is it what the team produces for industry implementation, or both? The primary purpose of this research is to identify what constitutes quality research that enables successful implementation so as to improve the construction industry. The objectives of this research are as follows:

- to define successful (and less than successful) construction industry project management research from the perspectives of both industry and academia
- to investigate research studies that have been acknowledged as successful by both industry and academia
- to identify the critical factors or attributes of successful research studies that have led to wide acceptance and implementation by both industry and academia
- to propose a research process model and/or to establish performance criteria for high-value project management research.

The data collection plan for the study has been broadly developed with two surveys to allow a comprehensive assessment of research products and the processes that produced these products. This survey requests data on the outputs of the research process—its products, tools, and practices—with the underlying assumption that products of value are likely to have been produced by successful research endeavors. If in addition to your knowledge of the implementation of specific CII practices, you have first-hand knowledge of the research processes of any individual research teams, please notify Junghye Son at junghye.son@utexas.edu or Steve Thomas at sthomas@mail.utexas.edu if you are willing to complete a survey addressing the research processes followed by these teams.

Ultimately the aggregated results of these surveys and quantitative analyses of CII product dissemination data will all be combined to guide a number of case studies. This comprehensive look at CII products and research teams should answer the research question in a rigorous manner. More importantly, it should help the CII Research Committee continue to refine its research process and thereby provide greater value to the CII membership.



RC Survey - CII Practices Assessment

Page 2

Instructions

The survey consists of two sections. **Section A** requests general information about you and your company for purposes of categorizing findings. **Section B** assesses CII practices and products in terms of **familiarity**, **implementability**, and **value**. Please respond to each section. If questions are not applicable to you and your organization, or if you lack knowledge of the specific practice or product, please indicate **Not Applicable** or **Unknown**. Individual responses to this survey are considered confidential and will not be shared with other industry members. Company-specific results will not be published or otherwise disclosed.

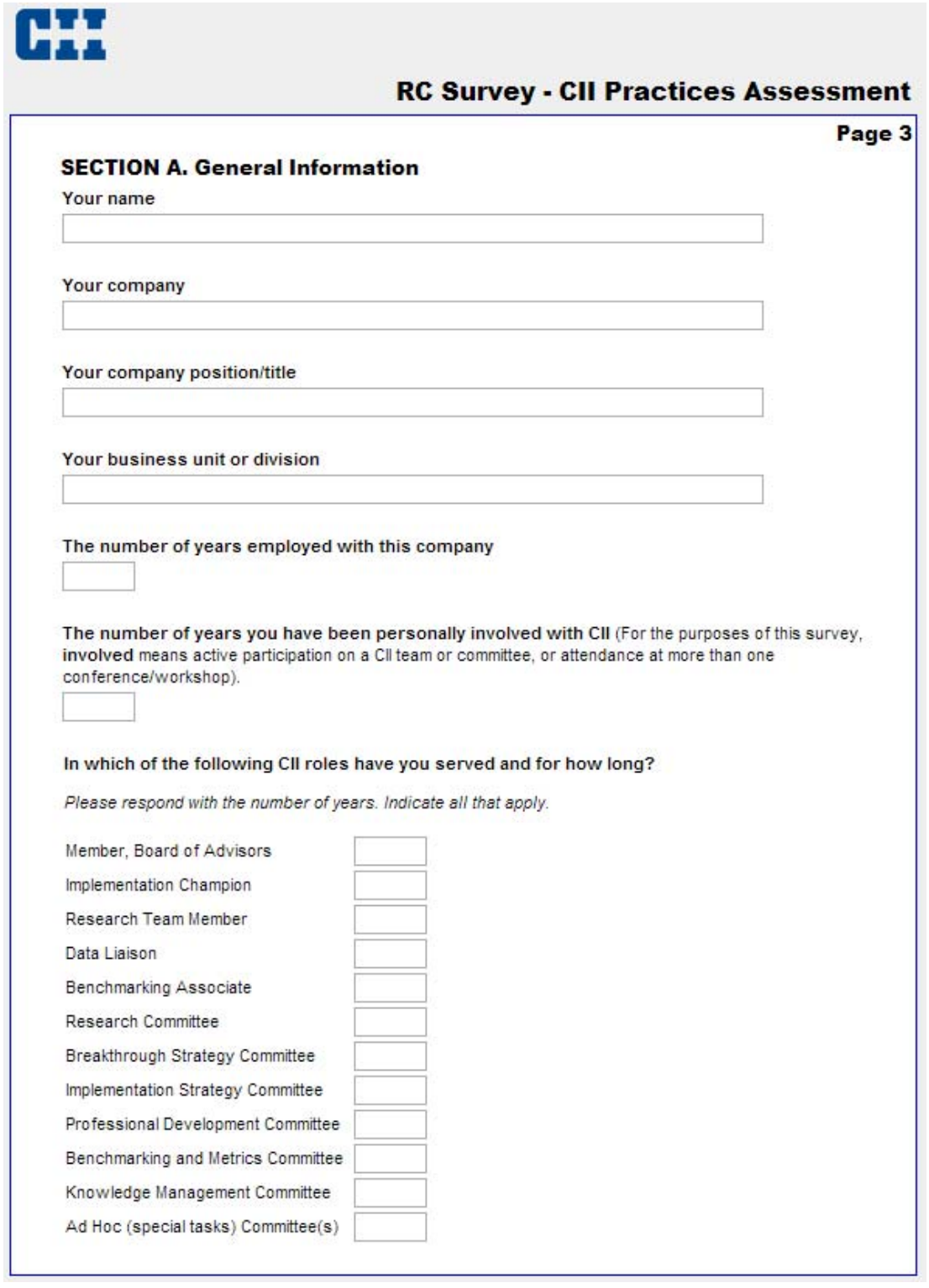
If you have questions or any comments regarding the survey, please contact Junghye Son at (512) 471-1408 or junghye.son@utexas.edu, or Steve Thomas at (512) 232-3007 or sthomas@cii.utexas.edu. Your participation in this CII research quality initiative is greatly appreciated.

Contact Information

Junghye Son
Graduate Research Assistant
Construction Engineering and Project Management Program
Department of Civil, Architectural and Environmental Engineering
The University of Texas at Austin
Construction Industry Institute
3925 West Braker Lane (R4500)
Phone: (512) 471-1408
Fax: (512) 499-8101
email: junghye.son@utexas.edu

Stephen R. Thomas, Ph.D., P.E.
Associate Director
Construction Industry Institute
3925 West Braker Lane (R4500)
Austin, Texas 78759-5316
Phone: (512) 232-3007
Fax: (512) 499-8101
email: sthomas@cii.utexas.edu

Appendix C, continued.



RC Survey - CII Practices Assessment

Page 3

SECTION A. General Information

Your name

Your company

Your company position/title

Your business unit or division

The number of years employed with this company

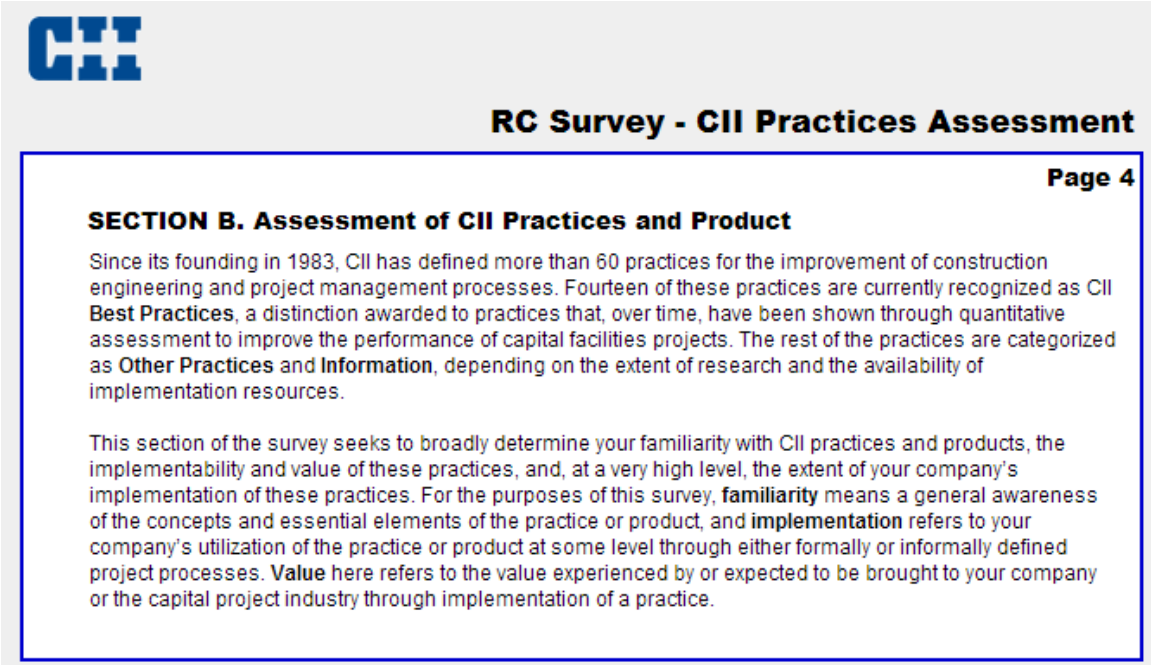
The number of years you have been personally involved with CII (For the purposes of this survey, **involved** means active participation on a CII team or committee, or attendance at more than one conference/workshop).

In which of the following CII roles have you served and for how long?

Please respond with the number of years. Indicate all that apply.

Member, Board of Advisors	
Implementation Champion	
Research Team Member	
Data Liaison	
Benchmarking Associate	
Research Committee	
Breakthrough Strategy Committee	
Implementation Strategy Committee	
Professional Development Committee	
Benchmarking and Metrics Committee	
Knowledge Management Committee	
Ad Hoc (special tasks) Committee(s)	

Appendix C, continued.



RC Survey - CII Practices Assessment

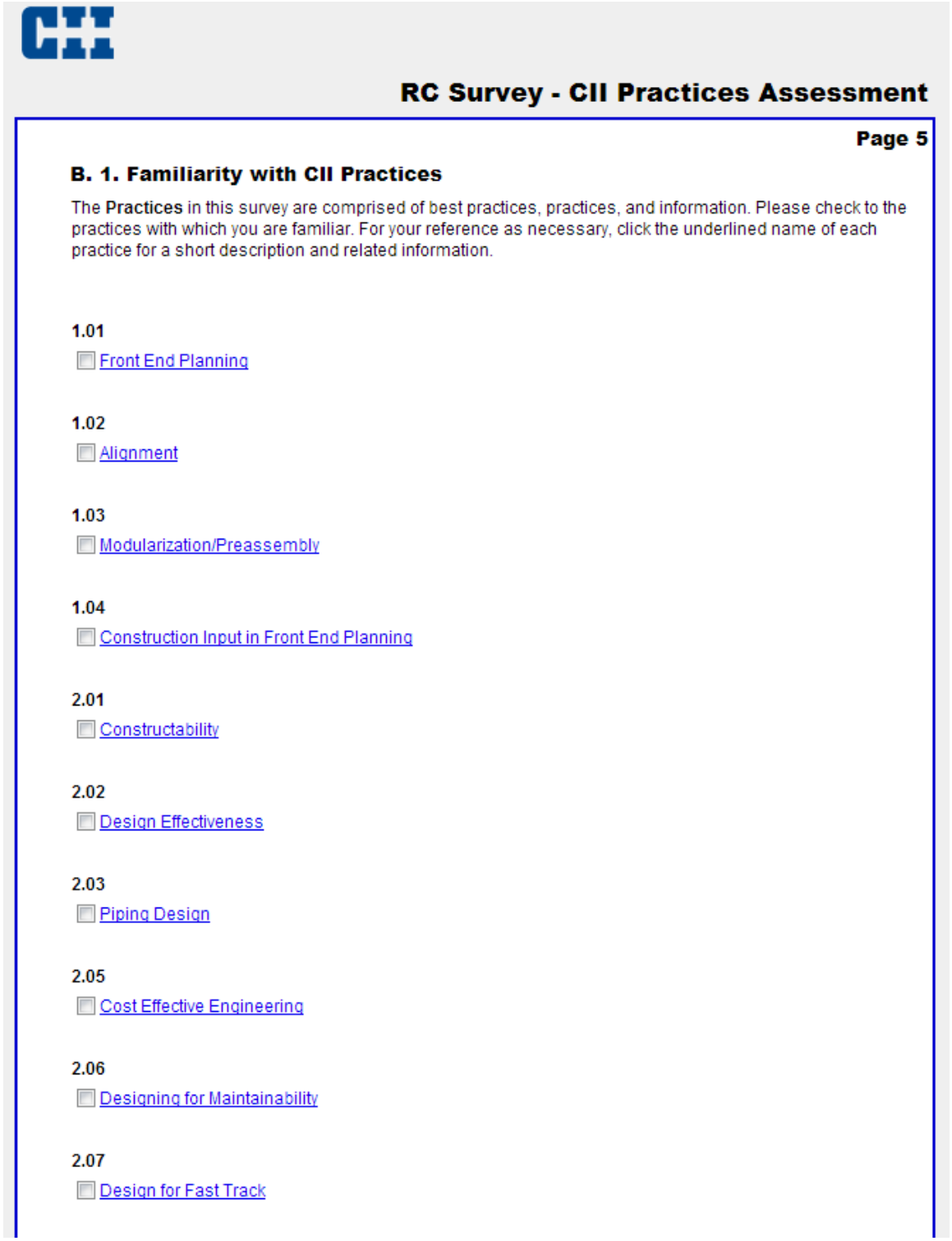
Page 4

SECTION B. Assessment of CII Practices and Product

Since its founding in 1983, CII has defined more than 60 practices for the improvement of construction engineering and project management processes. Fourteen of these practices are currently recognized as CII **Best Practices**, a distinction awarded to practices that, over time, have been shown through quantitative assessment to improve the performance of capital facilities projects. The rest of the practices are categorized as **Other Practices** and **Information**, depending on the extent of research and the availability of implementation resources.

This section of the survey seeks to broadly determine your familiarity with CII practices and products, the implementability and value of these practices, and, at a very high level, the extent of your company's implementation of these practices. For the purposes of this survey, **familiarity** means a general awareness of the concepts and essential elements of the practice or product, and **implementation** refers to your company's utilization of the practice or product at some level through either formally or informally defined project processes. **Value** here refers to the value experienced by or expected to be brought to your company or the capital project industry through implementation of a practice.

Appendix C, continued.



RC Survey - CII Practices Assessment

Page 5

B. 1. Familiarity with CII Practices

The **Practices** in this survey are comprised of best practices, practices, and information. Please check to the practices with which you are familiar. For your reference as necessary, click the underlined name of each practice for a short description and related information.

1.01
☐ Front End Planning

1.02
☐ Alignment

1.03
☐ Modularization/Preassembly

1.04
☐ Construction Input in Front End Planning

2.01
☐ Constructability

2.02
☐ Design Effectiveness

2.03
☐ Piping Design

2.05
☐ Cost Effective Engineering

2.06
☐ Designing for Maintainability

2.07
☐ Design for Fast Track

Appendix C, continued.

3.01
☐ Materials Management

3.02
☐ Supplier Relationships

4.02
☐ Lean Construction

4.03
☐ Assembly and Manufacturing Techniques

5.01
☐ Planning for Start-up

6.01
☐ Employee Incentives

6.02
☐ Management of Education and Training

6.03
☐ Attract and Maintain Skilled Workers

6.04
☐ Craft Productivity Practices

6.05
☐ Multi-skilling

6.06
☐ Engineering Productivity Measurement

7.01
☐ Team Building

7.02
☐ Partnering

7.03
☐ Organizational Work Structure

Appendix C, continued.

7.04
Leader Selection

7.05
Project Teams

8.01
Quality Management

8.02
Implementation of CII Research

8.03
Lessons Learned

8.04
Small Projects Execution

8.06
Work Process Simulation

8.07
Innovation and Technology Implementation

8.08
Value Management

8.09
Change Management

9.01
Cost & Schedule Control

9.02
Work Packaging

9.03
Project Health Assessment

9.04
Global Project Control and Management Systems

Appendix C, continued.

10.01
Disputes Prevention & Resolution

10.02
Project Delivery and Contract Strategies

10.03
Use of Project Incentives

10.04
Risk Management Basics and Insurance

10.05
Equitable Risk Allocation

10.06
International Project Risk Assessment

11.01
Zero Accidents Techniques

11.02
Environmental Remediation Management

11.03
Design for Safety

11.04
Managing Workers' Compensation

11.06
Sustainability

11.07
Safety Technologies

Appendix C, continued.

12.01

☐ Automated Identification

12.02

☐ Electronic Commerce

12.03

☐ Computer-aided Design/Drafting

12.04

☐ Information Integration

12.06

☐ Automation and Robotics

12.07

☐ Leveraging Technology to Improve Construction Productivity

12.09

☐ Building Information Modeling

13.02

☐ Global Construction Industry

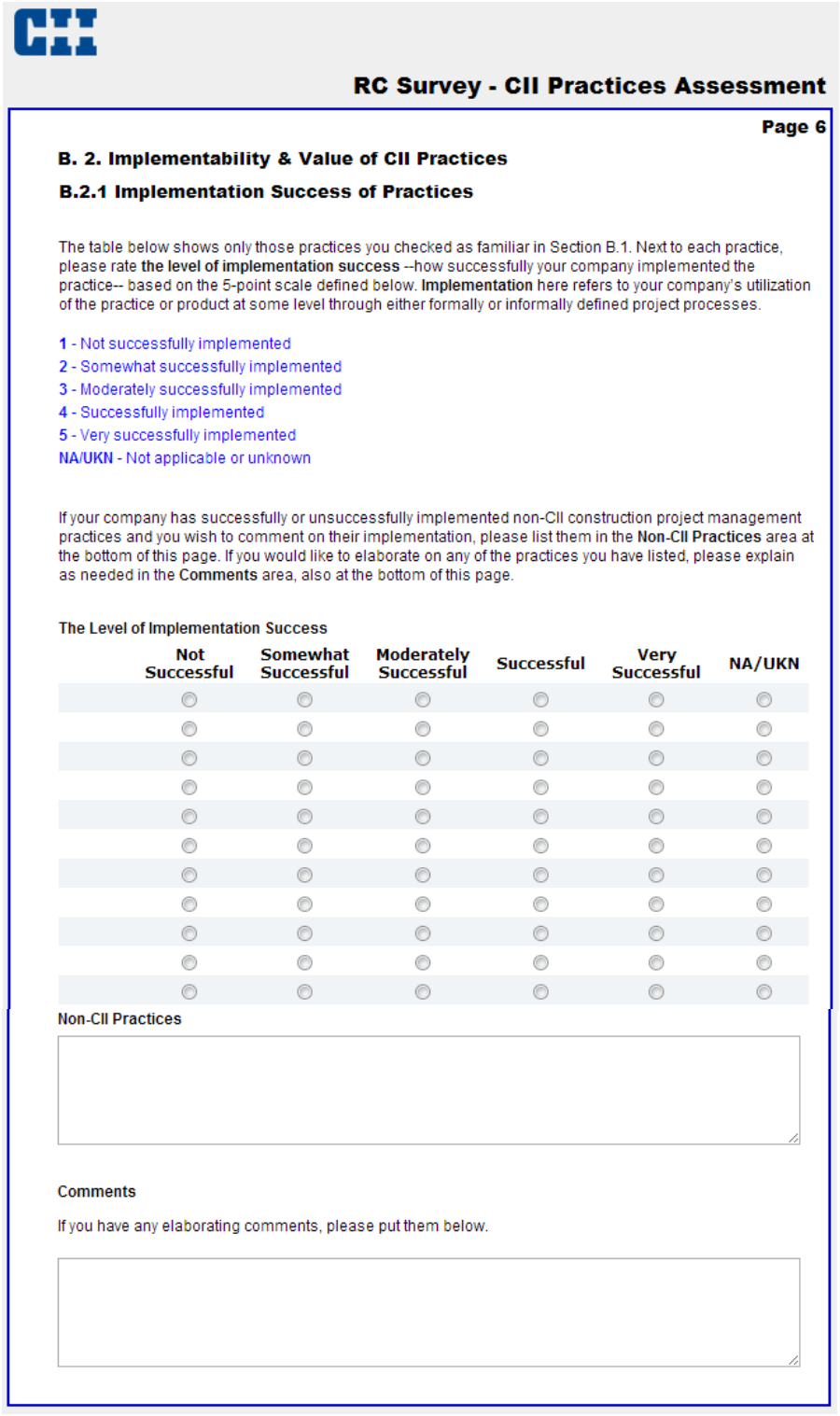
14.01

☐ Project Security

Comments

If you have any elaborating comments, please put them below.

Appendix C, continued.



RC Survey - CII Practices Assessment

Page 6

B. 2. Implementability & Value of CII Practices

B.2.1 Implementation Success of Practices

The table below shows only those practices you checked as familiar in Section B.1. Next to each practice, please rate **the level of implementation success** --how successfully your company implemented the practice-- based on the 5-point scale defined below. **Implementation** here refers to your company's utilization of the practice or product at some level through either formally or informally defined project processes.

1 - Not successfully implemented
2 - Somewhat successfully implemented
3 - Moderately successfully implemented
4 - Successfully implemented
5 - Very successfully implemented
NA/UKN - Not applicable or unknown

If your company has successfully or unsuccessfully implemented non-CII construction project management practices and you wish to comment on their implementation, please list them in the **Non-CII Practices** area at the bottom of this page. If you would like to elaborate on any of the practices you have listed, please explain as needed in the **Comments** area, also at the bottom of this page.

The Level of Implementation Success

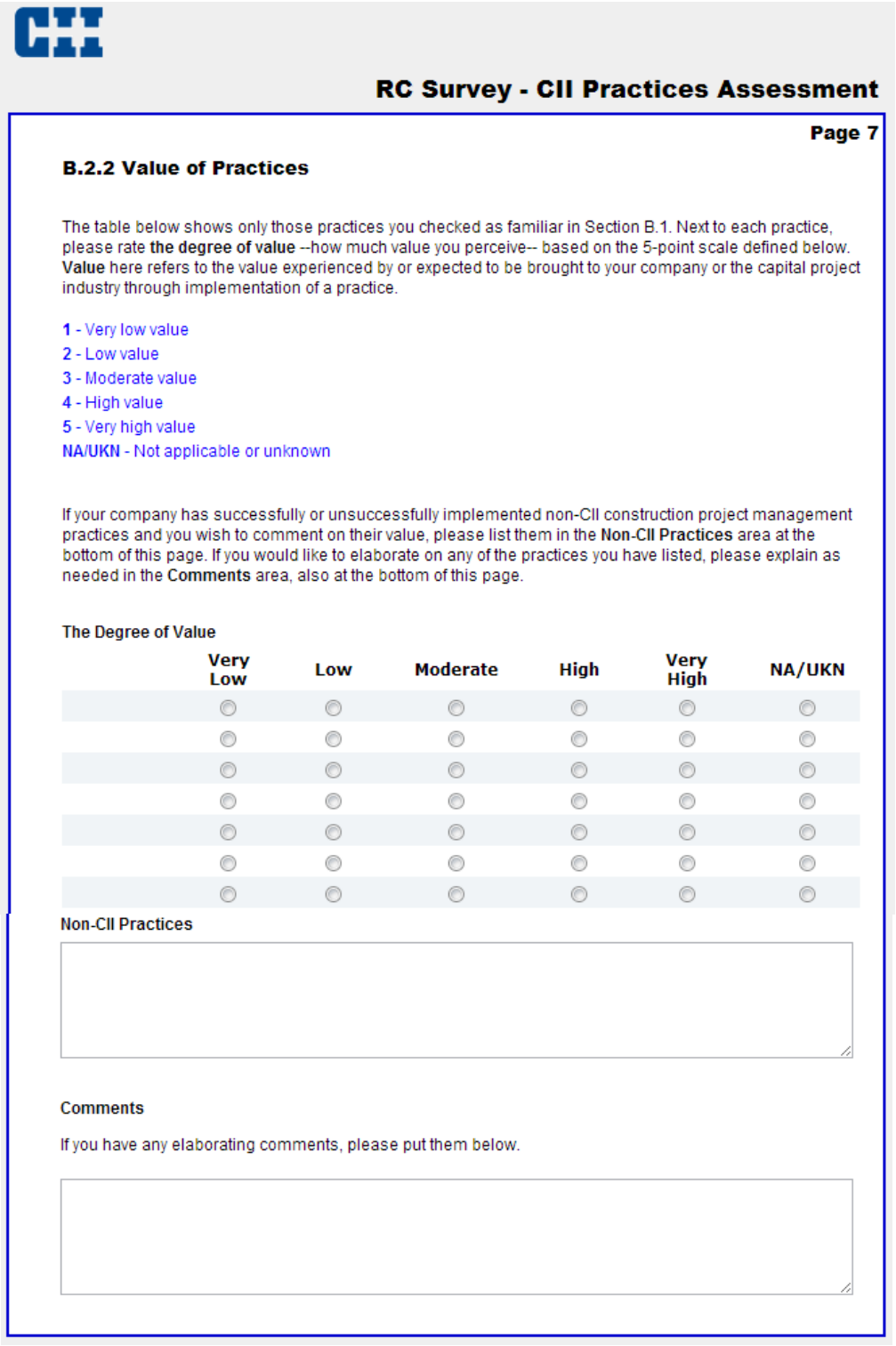
	Not Successful	Somewhat Successful	Moderately Successful	Successful	Very Successful	NA/UKN
	○	○	○	○	○	○
	○	○	○	○	○	○
	○	○	○	○	○	○
	○	○	○	○	○	○
	○	○	○	○	○	○
	○	○	○	○	○	○
	○	○	○	○	○	○
	○	○	○	○	○	○
	○	○	○	○	○	○
	○	○	○	○	○	○
	○	○	○	○	○	○

Non-CII Practices

Comments

If you have any elaborating comments, please put them below.

Appendix C, continued.



RC Survey - CII Practices Assessment

Page 7

B.2.2 Value of Practices

The table below shows only those practices you checked as familiar in Section B.1. Next to each practice, please rate **the degree of value** --how much value you perceive-- based on the 5-point scale defined below. **Value** here refers to the value experienced by or expected to be brought to your company or the capital project industry through implementation of a practice.

1 - Very low value
2 - Low value
3 - Moderate value
4 - High value
5 - Very high value
NA/UKN - Not applicable or unknown

If your company has successfully or unsuccessfully implemented non-CII construction project management practices and you wish to comment on their value, please list them in the **Non-CII Practices** area at the bottom of this page. If you would like to elaborate on any of the practices you have listed, please explain as needed in the **Comments** area, also at the bottom of this page.

The Degree of Value

	Very Low	Low	Moderate	High	Very High	NA/UKN
	○	○	○	○	○	○
	○	○	○	○	○	○
	○	○	○	○	○	○
	○	○	○	○	○	○
	○	○	○	○	○	○
	○	○	○	○	○	○
	○	○	○	○	○	○

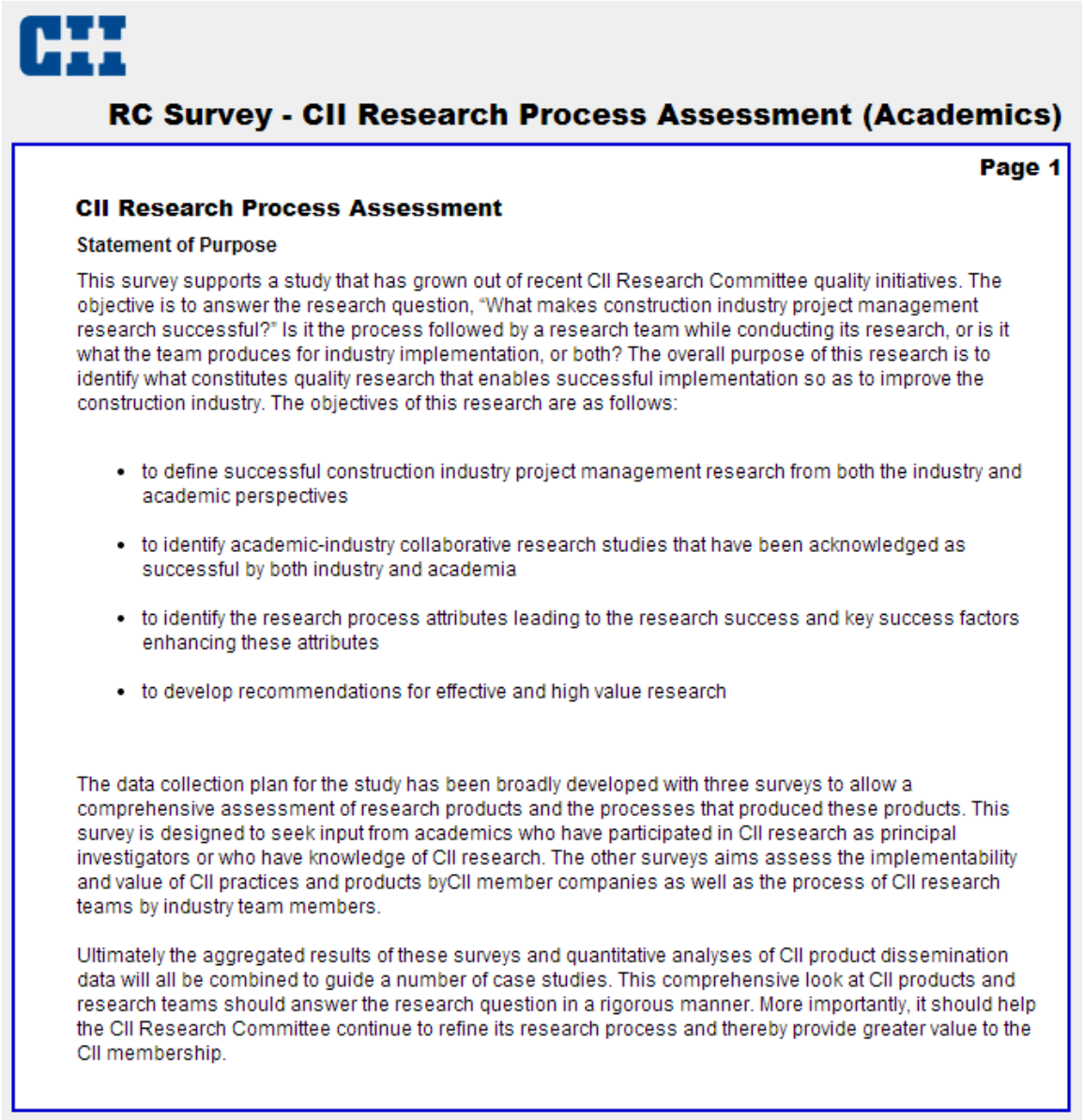
Non-CII Practices

Comments

If you have any elaborating comments, please put them below.

Appendix C, continued.

Appendix D: Academic Assessment Survey



RC Survey - CII Research Process Assessment (Academics)

Page 1

CII Research Process Assessment

Statement of Purpose

This survey supports a study that has grown out of recent CII Research Committee quality initiatives. The objective is to answer the research question, "What makes construction industry project management research successful?" Is it the process followed by a research team while conducting its research, or is it what the team produces for industry implementation, or both? The overall purpose of this research is to identify what constitutes quality research that enables successful implementation so as to improve the construction industry. The objectives of this research are as follows:

- to define successful construction industry project management research from both the industry and academic perspectives
- to identify academic-industry collaborative research studies that have been acknowledged as successful by both industry and academia
- to identify the research process attributes leading to the research success and key success factors enhancing these attributes
- to develop recommendations for effective and high value research

The data collection plan for the study has been broadly developed with three surveys to allow a comprehensive assessment of research products and the processes that produced these products. This survey is designed to seek input from academics who have participated in CII research as principal investigators or who have knowledge of CII research. The other surveys aims assess the implementability and value of CII practices and products byCII member companies as well as the process of CII research teams by industry team members.

Ultimately the aggregated results of these surveys and quantitative analyses of CII product dissemination data will all be combined to guide a number of case studies. This comprehensive look at CII products and research teams should answer the research question in a rigorous manner. More importantly, it should help the CII Research Committee continue to refine its research process and thereby provide greater value to the CII membership.

RC Survey - CII Research Process Assessment (Academics)

Instructions

The survey consists of three sections. **Section A** assesses CII practices and products in terms of **familiarity** and **value**. **Section B** asks you to assess research teams in which you have participated and/or of which you have knowledge based on the assessment criteria to be provided in the questionnaire. Please respond to each section.

If questions are not applicable to you, or if you lack knowledge of the specific practice, please indicate **Not Applicable** or **Unknown**. Individual responses to this survey are considered confidential and will not be shared with other academics or industry members.

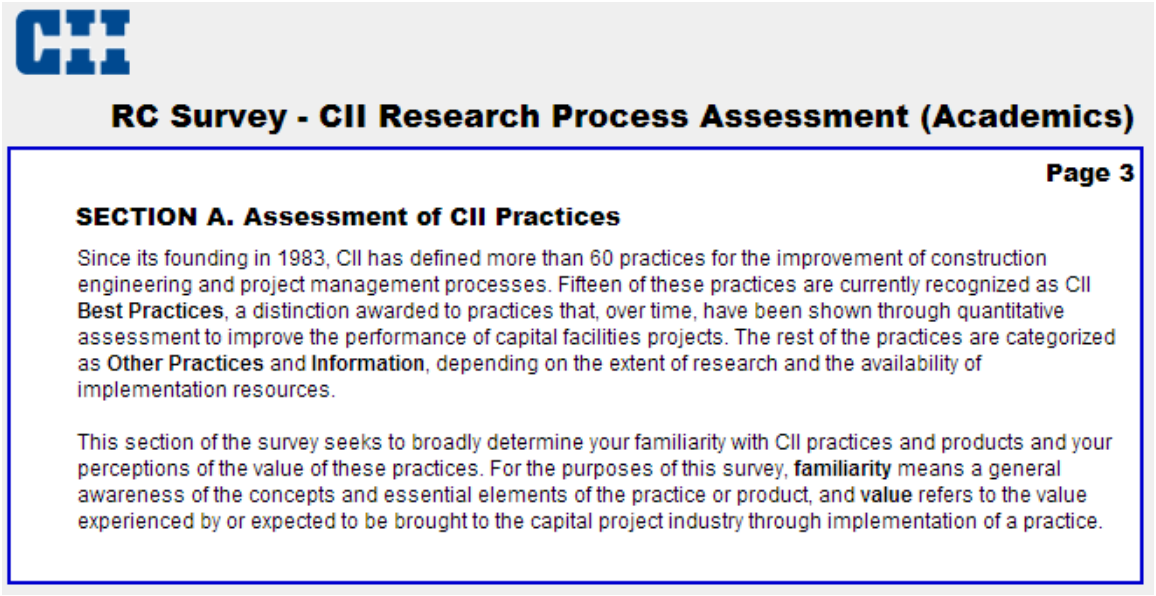
If you have questions or any comments regarding the survey, please contact Junghye Son at (512) 471-1408 or junghye.son@utexas.edu, or Steve Thomas at (512) 232-3007 or sthomas@cii.utexas.edu. Your participation in this CII research quality initiative is greatly appreciated.

Contact Information

Junghye Son
Graduate Research Assistant
Construction Engineering and Project Management Program
Department of Civil, Architectural and Environmental Engineering
The University of Texas at Austin
Construction Industry Institute
3925 West Braker Lane (R4500)
Phone: (512) 471-1408
Fax: (512) 499-8101
email: junghye.son@utexas.edu

Stephen R. Thomas, Ph.D., P.E.
Associate Director
Construction Industry Institute
3925 West Braker Lane (R4500)
Austin, Texas 78759-5316
Phone: (512) 232-3007
Fax: (512) 499-8101
email: sthomas@cii.utexas.edu

Appendix D, continued.



RC Survey - CII Research Process Assessment (Academics)

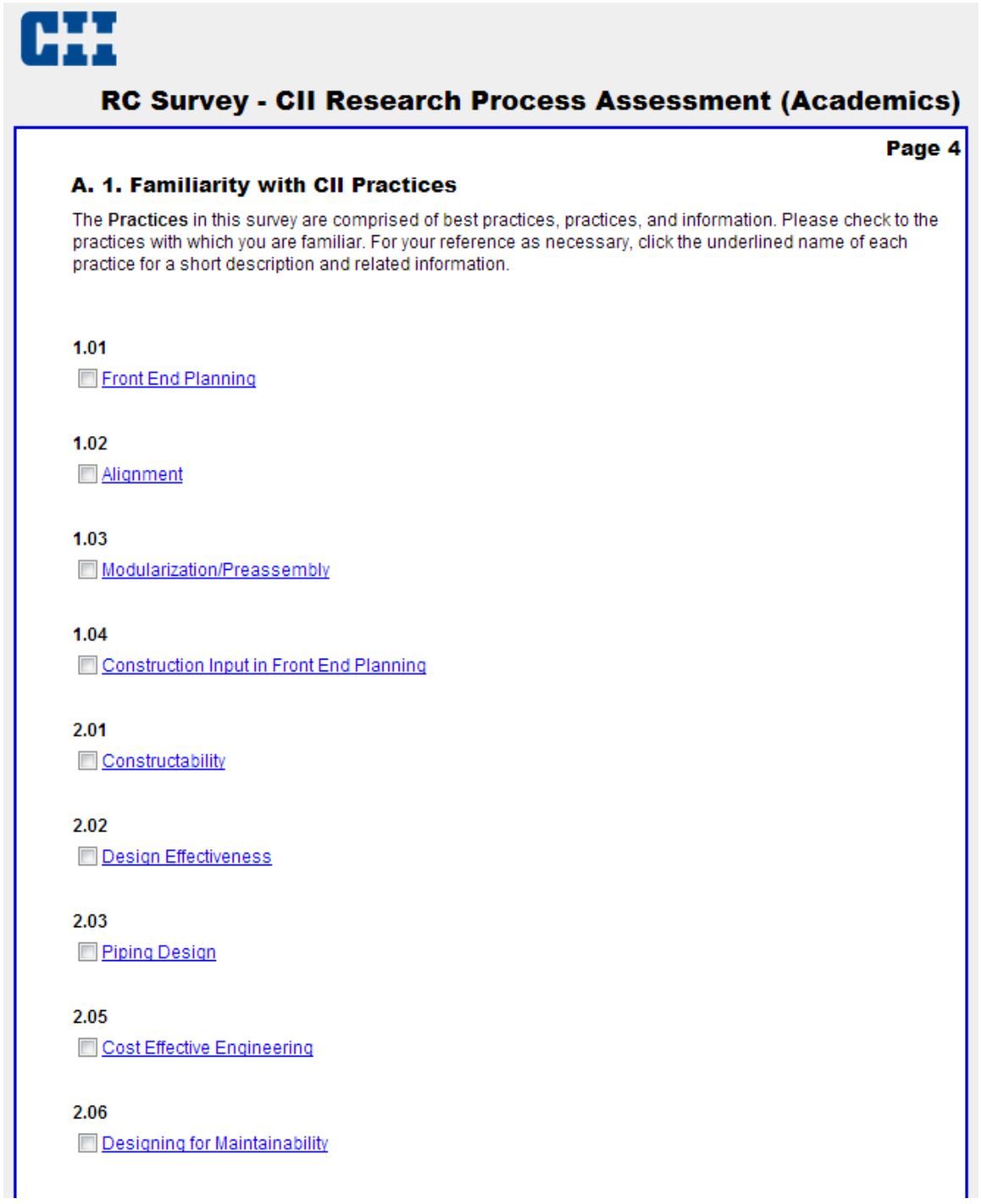
Page 3

SECTION A. Assessment of CII Practices

Since its founding in 1983, CII has defined more than 60 practices for the improvement of construction engineering and project management processes. Fifteen of these practices are currently recognized as CII **Best Practices**, a distinction awarded to practices that, over time, have been shown through quantitative assessment to improve the performance of capital facilities projects. The rest of the practices are categorized as **Other Practices** and **Information**, depending on the extent of research and the availability of implementation resources.

This section of the survey seeks to broadly determine your familiarity with CII practices and products and your perceptions of the value of these practices. For the purposes of this survey, **familiarity** means a general awareness of the concepts and essential elements of the practice or product, and **value** refers to the value experienced by or expected to be brought to the capital project industry through implementation of a practice.

Appendix D, continued.



RC Survey - CII Research Process Assessment (Academics)

Page 4

A. 1. Familiarity with CII Practices

The **Practices** in this survey are comprised of best practices, practices, and information. Please check to the practices with which you are familiar. For your reference as necessary, click the underlined name of each practice for a short description and related information.

1.01
☐ Front End Planning

1.02
☐ Alignment

1.03
☐ Modularization/Preassembly

1.04
☐ Construction Input in Front End Planning

2.01
☐ Constructability

2.02
☐ Design Effectiveness

2.03
☐ Piping Design

2.05
☐ Cost Effective Engineering

2.06
☐ Designing for Maintainability

Appendix D, continued.

2.07
☐ Design for Fast Track

3.01
☐ Materials Management

3.02
☐ Supplier Relationships

4.02
☐ Lean Construction

4.03
☐ Assembly and Manufacturing Techniques

5.01
☐ Planning for Start-up

6.01
☐ Employee Incentives

6.02
☐ Management of Education and Training

6.03
☐ Attract and Maintain Skilled Workers

6.04
☐ Craft Productivity Practices

6.05
☐ Multi-skilling

6.06
☐ Engineering Productivity Measurement

7.01
☐ Team Building

Appendix D, continued.

7.02
☐ Partnering

7.03
☐ Organizational Work Structure

7.04
☐ Leader Selection

7.05
☐ Project Teams

8.01
☐ Quality Management

8.02
☐ Implementation of CII Research

8.03
☐ Lessons Learned

8.04
☐ Small Projects Execution

8.06
☐ Work Process Simulation

8.07
☐ Innovation and Technology Implementation

8.08
☐ Value Management

8.09
☐ Change Management

9.01
☐ Cost & Schedule Control

Appendix D, continued.

9.02
☐ Work Packaging

9.03
☐ Project Health Assessment

9.04
☐ Global Project Control and Management Systems

10.01
☐ Disputes Prevention & Resolution

10.02
☐ Project Delivery and Contract Strategies

10.03
☐ Use of Project Incentives

10.04
☐ Risk Management Basics and Insurance

10.05
☐ Equitable Risk Allocation

10.06
☐ International Project Risk Assessment

11.01
☐ Zero Accidents Techniques

11.02
☐ Environmental Remediation Management

11.03
☐ Design for Safety

11.04
☐ Managing Workers' Compensation

11.06
☐ Sustainability

Appendix D, continued.

11.07

☐ Safety Technologies

12.01

☐ Automated Identification

12.02

☐ Electronic Commerce

12.03

☐ Computer-aided Design/Drafting

12.04

☐ Information Integration

12.06

☐ Automation and Robotics

12.07

☐ Leveraging Technology to Improve Construction Productivity

12.09

☐ Building Information Modeling

13.02

☐ Global Construction Industry

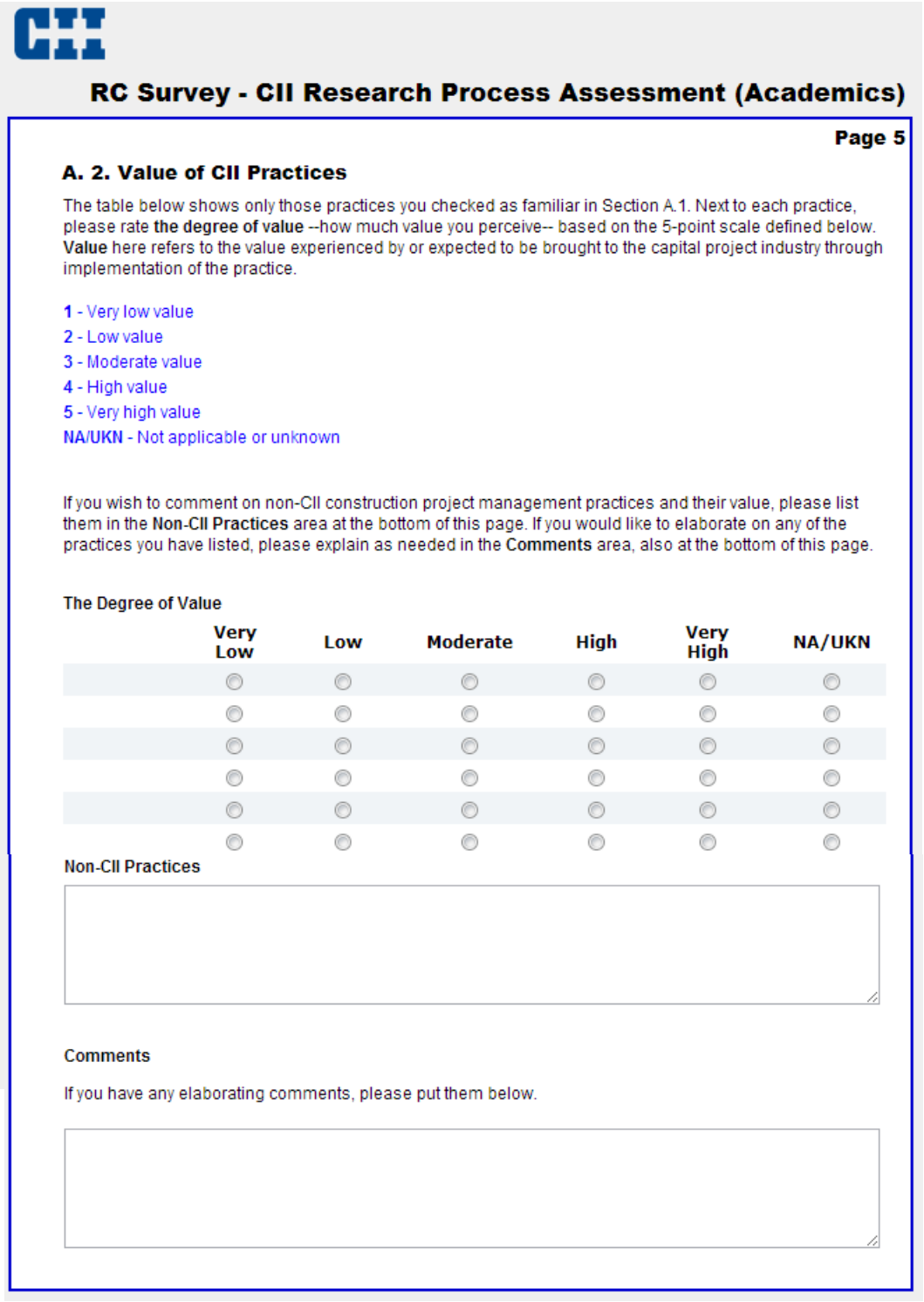
14.01

☐ Project Security

Comments

If you have any elaborating comments, please put them below.

Appendix D, continued.



RC Survey - CII Research Process Assessment (Academics)

Page 5

A. 2. Value of CII Practices

The table below shows only those practices you checked as familiar in Section A.1. Next to each practice, please rate **the degree of value** --how much value you perceive-- based on the 5-point scale defined below. **Value** here refers to the value experienced by or expected to be brought to the capital project industry through implementation of the practice.

1 - Very low value
2 - Low value
3 - Moderate value
4 - High value
5 - Very high value
NA/UKN - Not applicable or unknown

If you wish to comment on non-CII construction project management practices and their value, please list them in the **Non-CII Practices** area at the bottom of this page. If you would like to elaborate on any of the practices you have listed, please explain as needed in the **Comments** area, also at the bottom of this page.

The Degree of Value

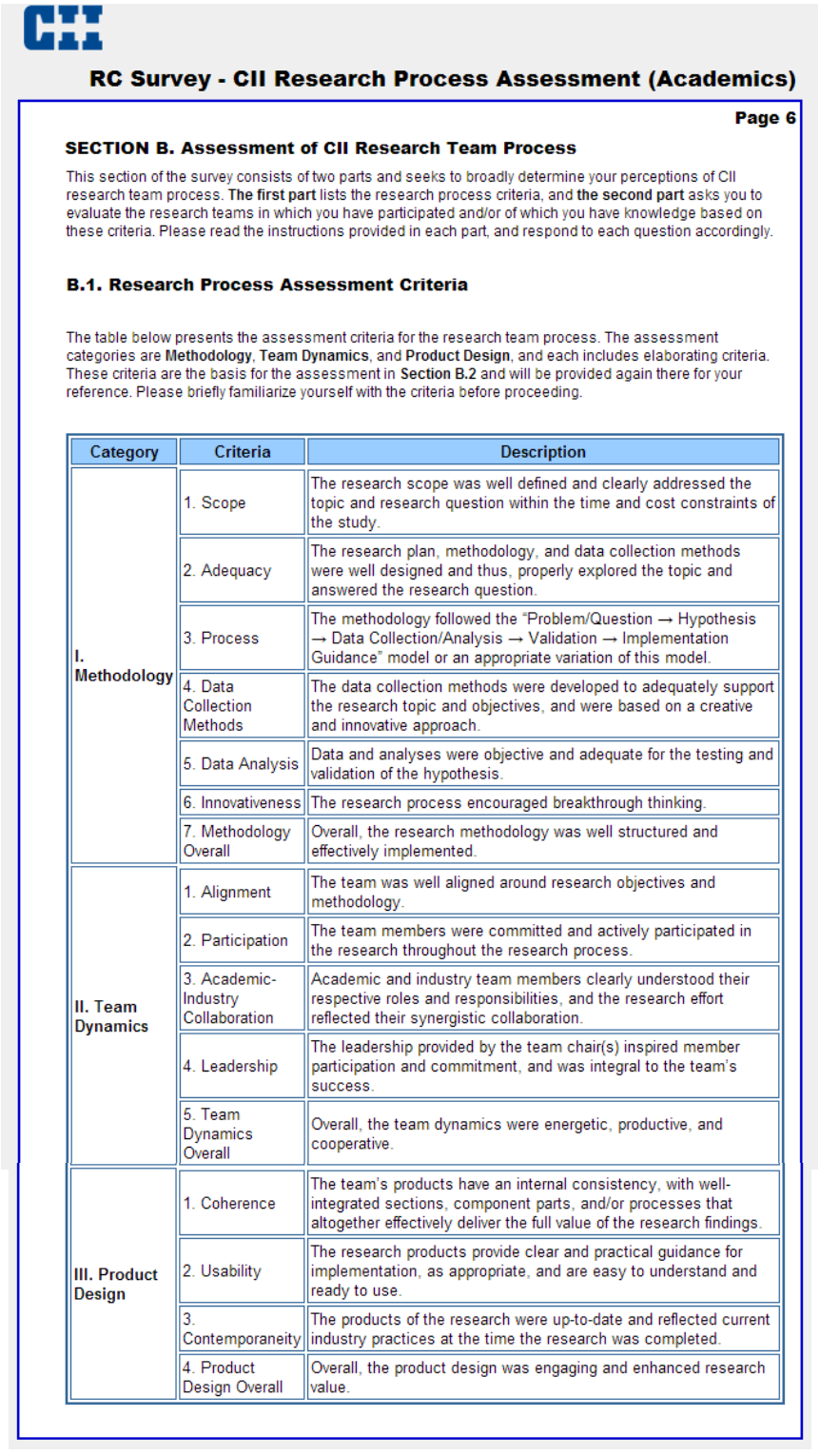
	Very Low	Low	Moderate	High	Very High	NA/UKN
	○	○	○	○	○	○
	○	○	○	○	○	○
	○	○	○	○	○	○
	○	○	○	○	○	○
	○	○	○	○	○	○
	○	○	○	○	○	○

Non-CII Practices

Comments

If you have any elaborating comments, please put them below.

Appendix D, continued.



RC Survey - CII Research Process Assessment (Academics)

Page 6

SECTION B. Assessment of CII Research Team Process

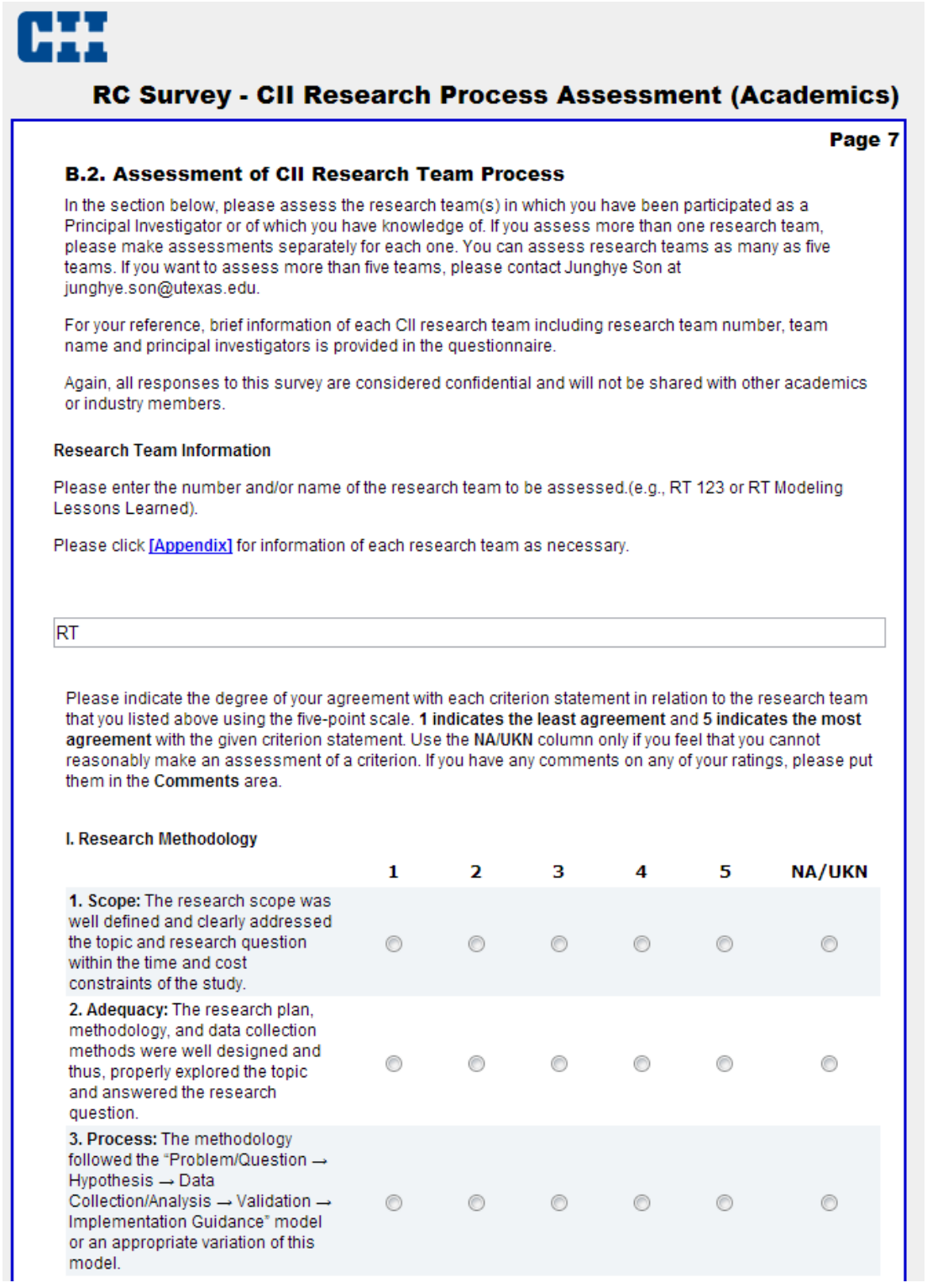
This section of the survey consists of two parts and seeks to broadly determine your perceptions of CII research team process. **The first part** lists the research process criteria, and **the second part** asks you to evaluate the research teams in which you have participated and/or of which you have knowledge based on these criteria. Please read the instructions provided in each part, and respond to each question accordingly.

B.1. Research Process Assessment Criteria

The table below presents the assessment criteria for the research team process. The assessment categories are **Methodology**, **Team Dynamics**, and **Product Design**, and each includes elaborating criteria. These criteria are the basis for the assessment in **Section B.2** and will be provided again there for your reference. Please briefly familiarize yourself with the criteria before proceeding.

Category	Criteria	Description
I. Methodology	1. Scope	The research scope was well defined and clearly addressed the topic and research question within the time and cost constraints of the study.
	2. Adequacy	The research plan, methodology, and data collection methods were well designed and thus, properly explored the topic and answered the research question.
	3. Process	The methodology followed the "Problem/Question → Hypothesis → Data Collection/Analysis → Validation → Implementation Guidance" model or an appropriate variation of this model.
	4. Data Collection Methods	The data collection methods were developed to adequately support the research topic and objectives, and were based on a creative and innovative approach.
	5. Data Analysis	Data and analyses were objective and adequate for the testing and validation of the hypothesis.
	6. Innovativeness	The research process encouraged breakthrough thinking.
	7. Methodology Overall	Overall, the research methodology was well structured and effectively implemented.
II. Team Dynamics	1. Alignment	The team was well aligned around research objectives and methodology.
	2. Participation	The team members were committed and actively participated in the research throughout the research process.
	3. Academic-Industry Collaboration	Academic and industry team members clearly understood their respective roles and responsibilities, and the research effort reflected their synergistic collaboration.
	4. Leadership	The leadership provided by the team chair(s) inspired member participation and commitment, and was integral to the team's success.
	5. Team Dynamics Overall	Overall, the team dynamics were energetic, productive, and cooperative.
III. Product Design	1. Coherence	The team's products have an internal consistency, with well-integrated sections, component parts, and/or processes that altogether effectively deliver the full value of the research findings.
	2. Usability	The research products provide clear and practical guidance for implementation, as appropriate, and are easy to understand and ready to use.
	3. Contemporaneity	The products of the research were up-to-date and reflected current industry practices at the time the research was completed.
	4. Product Design Overall	Overall, the product design was engaging and enhanced research value.

Appendix D, continued.



RC Survey - CII Research Process Assessment (Academics)

Page 7

B.2. Assessment of CII Research Team Process

In the section below, please assess the research team(s) in which you have been participated as a Principal Investigator or of which you have knowledge of. If you assess more than one research team, please make assessments separately for each one. You can assess research teams as many as five teams. If you want to assess more than five teams, please contact Junghye Son at junghye.son@utexas.edu.

For your reference, brief information of each CII research team including research team number, team name and principal investigators is provided in the questionnaire.

Again, all responses to this survey are considered confidential and will not be shared with other academics or industry members.

Research Team Information

Please enter the number and/or name of the research team to be assessed.(e.g., RT 123 or RT Modeling Lessons Learned).

Please click [Appendix] for information of each research team as necessary.

RT

Please indicate the degree of your agreement with each criterion statement in relation to the research team that you listed above using the five-point scale. **1 indicates the least agreement** and **5 indicates the most agreement** with the given criterion statement. Use the **NA/UKN** column only if you feel that you cannot reasonably make an assessment of a criterion. If you have any comments on any of your ratings, please put them in the **Comments** area.

I. Research Methodology

	1	2	3	4	5	NA/UKN
1. Scope: The research scope was well defined and clearly addressed the topic and research question within the time and cost constraints of the study.	○	○	○	○	○	○
2. Adequacy: The research plan, methodology, and data collection methods were well designed and thus, properly explored the topic and answered the research question.	○	○	○	○	○	○
3. Process: The methodology followed the "Problem/Question → Hypothesis → Data Collection/Analysis → Validation → Implementation Guidance" model or an appropriate variation of this model.	○	○	○	○	○	○

Appendix D, continued.

4. Data Collection Methods: The data collection methods were developed to adequately support the research topic and objectives, and were based on a creative and innovative approach.						
5. Data Analysis: Data and analyses were objective and adequate for the testing and validation of the hypothesis.						
6. Innovativeness: The research process encouraged breakthrough thinking.						
7. Methodology Overall: Overall, the research methodology was well structured and effectively implemented.						

II. Team Dynamics

	1	2	3	4	5	NA/UKN
1. Alignment: The team was well aligned around research objectives and methodology.						
2. Participation: The team members were committed and actively participated in the research throughout the research process.						
3. Academic-Industry Collaboration Academic and industry team members clearly understood their respective roles and responsibilities, and the research effort reflected their synergistic collaboration.						
4. Leadership: The leadership provided by the team chair(s) inspired member participation and commitment, and was integral to the team's success.						
5. Team Dynamics Overall: Overall, the team dynamics were energetic, productive, and cooperative.						

Appendix D, continued.

III. Product Design

	1	2	3	4	5	NA/UKN
1. Coherence: The team's products have an internal consistency, with well-integrated sections, component parts, and/or processes that altogether effectively deliver the full value of the research findings.	○	○	○	○	○	○
2. Usability: The research products provide clear and practical guidance for implementation, as appropriate, and are easy to understand and ready to use.	○	○	○	○	○	○
3. Contemporaneity: The products of the research were up-to-date and reflected current industry practices at the time the research was completed.	○	○	○	○	○	○
4. Product Design Overall: Overall, the product design was engaging and enhanced research value.	○	○	○	○	○	○

Comments

If you have any elaborating comments, please put them below.

RC Survey - CII Research Process Assessment (Academics)

Page 8

Are you willing to assess another research team?

○ Yes ○ No

Appendix D, continued.

Appendix E: Case Research Teams Nomination Form

The purpose of this form is to select candidate research teams among CII RT250 to RT294 for the cases studies of the research. This nomination form has three sections. The first section asks you to list five successful research teams and five less than successful research teams. The second section asks you to select three research teams each for successful and less than successful research effort in terms of research methodology, team dynamics, and product design. The third section asks you to choose three research teams that you expect to be successful in implementation and to have higher value, and three research teams that you anticipate to be less than successful in implementation and to have lower value.

Refer Appendix I. for research team information and refer Appendix II. for descriptions of research process attributes, which include research methodology, team dynamics, and product design, as necessary.

Your name:

_____

Company (or Institution):

_____

I.	**In this section, please select up to five research teams for each of successful research and less than successful research. Please refer Appendix I as necessary.**	
1.	**Please list your top five choices for the case studies on successful research.** Please explain your reason(s) next to each choice.	
	Your Choices	***Main Reason(s)***
	Choice 1. RT _____	
	Choice 2. RT _____	
	Choice 3. RT _____	
	Choice 4. RT _____	
	Choice 5. RT _____	
	Comments:	
2.	**Please list your top five choices for the case studies on less than successful research.** Refer Appendix A. for research team information as necessary. Please explain your reason(s) next to each choice.	
	Your Choices	***Main Reason(s)***
	Choice 1. RT _____	
	Choice 2. RT _____	
	Choice 3. RT _____	
	Choice 4. RT _____	
	Choice 5. RT _____	
	Comments:	

II.	**In this section, please select up to three research teams for successful research and less than successful research for research methodology, team dynamics, and product design. Please refer Appendix II as necessary.**	
1.	Please list your top three choices of research teams that were successful in terms of Research Methodology. Please explain your reason(s) next to each choice.	
	Research Methodology	***Main Reason(s)***
	Choice 1. RT _____	
	Choice 2. RT _____	
	Choice 3. RT _____	
	Comments:	
2.	Please list your top three choices of research teams that were less than successful in terms of Research Methodology. Please explain your reason(s) next to each choice.	
	Research Methodology	***Main Reason(s)***
	Choice 1. RT _____	
	Choice 2. RT _____	
	Choice 3. RT _____	
	Comments:	

Appendix E, continued.

3.	Please list your top three choices of research teams that were successful in terms of Team Dynamics. Please explain your reason(s) next to each choice.	
	Team Dynamics	***Main Reason(s)***
	Choice 1. RT _____	
	Choice 2. RT _____	
	Choice 3. RT _____	
	Comments:	
4.	Please list your top three choices of research teams that were less than successful in terms of Team Dynamics. Please explain your reason(s) next to each choice.	
	Team Dynamics	***Main Reason(s)***
	Choice 1. RT _____	
	Choice 2. RT _____	
	Choice 3. RT _____	
	Comments:	
5.	Please list your top three choices of research teams that were successful in terms of Product Design. Please explain your reason(s) next to each choice.	
	Product Design	***Main Reason(s)***
	Choice 1. RT _____	
	Choice 2. RT _____	
	Choice 3. RT _____	
	Comments:	

Appendix E, continued.

6.	Please list your top three choices of research teams that were less than successful in terms of Product Design. Please explain your reason(s) next to each choice.	
	Product Design	***Main Reason(s)***
	Choice 1. RT _____	
	Choice 2. RT _____	
	Choice 3. RT _____	
	Comments:	
III.	**In this section, please list up to three research teams for successful research and less than successful research from the perspectives of implementability and value.**	
1.	Please list your top three five of research teams that have high potential of being successful in terms of implementability. Please explain your reason(s) next to each choice.	
	Implementability	***Main Reason(s)***
	Choice 1. RT _____	
	Choice 2. RT _____	
	Choice 3. RT _____	
	Comments:	

Appendix E, continued.

2.	Please list your top three five of research teams that have high potential of being less than successful in terms of implementability. Please explain your reason(s) next to each choice.	
	Implementability	***Main Reason(s)***
	Choice 1. RT _____	
	Choice 2. RT _____	
	Choice 3. RT _____	
	Comments:	
3.	Please list your top three five of research teams that have high potential of being successful in terms of value. Please explain your reason(s) next to each choice.	
	Value	***Main Reason(s)***
	Choice 1. RT _____	
	Choice 2. RT _____	
	Choice 3. RT _____	
	Comments:	

Appendix E, continued.

4.	Please list your top three five of research teams that have high potential of being less than successful in terms of value. Please explain your reason(s) next to each choice.	
	Value	***Main Reason(s)***
	Choice 1. RT _____	
	Choice 2. RT _____	
	Choice 3. RT _____	
	Comments:	
	Please provide any additional comments.	

Use the space provided below for any additional comments.

Thank you for providing your valuable input.

Appendix E, continued.

Appendix I. CII Research Teams (250s~290s)

RT No	Name	Start Year	End Year
250	Sustainable Design and Construction	2007	2008
251	Nanotechnology and its Impact on Construction	2007	2008
252	Craft Productivity Research Program	2007	
253	Estimating as a Competency in Capital Projects	2007	2009
254	Quality Management Best Practice Refresh	2007	2009
255	Adaptation of Shipbuilding Production Systems to Construction	2007	2009
256	Project Site Leadership Role in Improving Construction Safety	2007	2010
257	Global Procurement & Materials Management Best Practice Refresh	2007	2009
258	Information Integration to Improve Capital Project Performance	2007	2009
260	Reimbursable Contracts	2008	2011
261	Optimizing Jobsite Organization	2008	2011
263	Globalization	2008	2010
264	Product Integrity Concerns in Low-Cost Sourcing Countries	2008	2010
265	How Do We Use Industrial Engineering/ Manufacturing Techniques for Enhancing Construction Project Performance?	2008	2010
266	A Standardized Approach to Identify and Define Owner Value Interests and Align the E&C Response	2008	2010
268	Project Definition Rating Index Tool for Infrastructure Projects	2008	2010
269	Real-time Pro-Active Safety in Construction	2008	2010

Appendix E, continued.

RT No	Name	Start Year	End Year
270	Applicability of CII Best Practices by Industry Sector and Project Type	2009	2011
271	Innovative Project Delivery Processes -- Is There a Better Way?	2009	2011
272	Enhanced Work Packaging: Design through WorkFace Execution	2009	2011
280	Methods for Dealing with Uncertainty - Applying Probabilistic Controls in Construction	2010	
281	Project Management Skills of the Future -	2010	
282	Managing Indirect Costs	2010	
283	Modularization	2010	
284	Leading Indicators for Safety	2010	
290	Quantifying the Impact of Change from Project Authorization to Startup	2011	
291	Improving the Accuracy of Project Outcome Predictions	2011	
292	Knowledge Transfer from the Near-Retirement Generation to the Next Generation	2011	
293	Strategies for HSE Hazard Recognition	2011	
294	Deploying Best Practices in Developing Countries	2011	

Appendix E, continued.

Appendix II. Research Process Attribute Table

Category	Criteria	Description
I. Methodology	**1. Scope**	The research scope was well defined and clearly addressed the topic and research question within the time and cost constraints of the study.
	2. Adequacy	The research plan, methodology, and data collection methods were well designed and thus, properly explored the topic and answered the research question.
	3. Process	The methodology followed the "Problem/Question → Hypothesis → Data Collection/Analysis → Validation → Implementation Guidance" model or an appropriate variation of this model.
	4. Data Collection Methods	The data collection methods were developed to adequately support the research topic and objectives, and were based on a creative and innovative approach.
	5. Data Analysis	Data and analyses were objective and adequate for the testing and validation of the hypothesis.
	6. Innovativeness	The research process encouraged breakthrough thinking.
	7. Methodology Overall	Overall, the research methodology was well structured and effectively implemented.
	4. Product Design Overall	Overall, the product design was engaging and enhanced research value.

Appendix E, continued.

Category	Criteria	Description
II. Team Dynamics	**1. Alignment**	The team was well aligned around research objectives and methodology.
	2. Participation	The team members were committed and actively participated in the research throughout the research process.
	3. Academic-Industry Collaboration	Academic and industry team members clearly understood their respective roles and responsibilities, and the research effort reflected their synergistic collaboration.
	4. Leadership	The leadership provided by the team chair(s) inspired member participation and commitment, and was integral to the team's success.
	5. Team Dynamics Overall	Overall, the team dynamics were energetic, productive, and cooperative.
III. Product Design	**1. Coherence**	The team's products have an internal consistency, with well-integrated sections, component parts, and/or processes that altogether effectively deliver the full value of the research findings.
	2. Usability	The research products provide clear and practical guidance for implementation, as appropriate, and are easy to understand and ready to use.
	3. Contemporaneity	The products of the research were up-to-date and reflected current industry practices at the time the research was completed.
	4. Product Design Overall	Overall, the product design was engaging and enhanced research value.

Appendix E, continued.

Appendix F: Interview Guide for Case Studies

1. Participation Information

a) Personal Background – industry experience, job position
b) Experience with CII and/or CII Research
c) Roles & Responsibilities on Team – PI, Chair, Sub-team Leader, AC Presenter, Publication Author

2. Research Process

a) Research Methodology
   1) Scope: Was the scope appropriately defined to effectively address the research topic/question, and objectives and was it realistic for the research timeframe expected?
   2) Methodology: Was the methodology sound for performing the research in the expected CII mode?
   3) Data collection and analysis: What approach was used for data collection and analysis and was it effective for supporting the research?
   4) Use of the industry team: Were innovative ideas used to maximize the opportunities afforded by the industry participants on the team?

b) Team Dynamics
   1) Team alignment: Were the research team members aligned concerning the purpose, objectives, methodology, and research plan?
   2) Participation: Was the team successful considering meeting attendance, intellectual contributions, task assignment, sub-team activities?
   3) Academic-industry collaboration: Was there a good balance between academic and industry expertise, and did the team benefit from a related synergistic effect?
   4) Leadership: How would you characterize the leadership of this team? Was it industry or academic led, or was there a balance between the two?
   5) Team interactions/relationships: How would you characterize opportunities for networking, social activities, personal relationships, and the overall atmosphere, and cohesiveness of the team?

c) Product Design (RS/IR/RR)
   1) How would you characterize the overall quality of the deliverables including, models, tools, techniques, findings, and recommendations of the publications?

2) How would you assess the usability, practicality, timing, and relevance to topic for the deliverables?
3) What is your feedback on use of products since the team sunset?

3. Additional Information

a) Lessons Learned
1) What lessons learned could you offer to build upon this experience and help improve the experience and performance of other research teams?
2) What are the strengths and/or weaknesses of this team?
3) What do you consider to be the most significant challenge that this RT faced and how did the team (or participant) responded to overcome it?
4) What similarities and/or differences do you consider to be noteworthy between this research team and other research teams that you participated on?

b) Research Outcomes
1) Please briefly comment on the implementability and value of research products produced by team.
2) Please briefly comment on any personal benefits that you or other team members derived from participation on the team.

c) Please provide and additional recommendations to improve CII Research.

Appendix G: Interview Questions for Academics

Research Team #_____ Interview Date:

Personal Background

1. Institution name: _____
2. Position/title: _____
3. Domain of expertise: _____
4. The number of years in academia: _____
5. The number of years involved with CII (active participation on a CII team or committee, or attendance at more than one conference/workshop): _____
6. CII roles served (Indicate all that apply with the number of years served.):
   - Research Committee _____
   - Academic Committee _____
   - Breakthrough Strategy Committee _____
   - Implementation Strategy Committee _____
   - Professional Development Committee _____
   - Benchmarking and Metrics Committee _____
   - Knowledge Management Committee _____
   - Ad Hoc (special tasks) Committee(s) _____

7. Previous experience with CII research team(s) (research team number or name):
   - _____
8. Research experience other than CII research (research title and year):
   - _____

Research Process

I. Overall Questions

A. Strengths and weaknesses

1. What were some strengths and weaknesses/challenges in regard to the research process of this team? For example, in terms of research methodology, team dynamics, and product design and development.
2. If there were any unique aspects or innovative approaches in this team, please explain them.

B. Research phases

Could you briefly describe the research phases such as timeframe and key activities?

II. Research Methodology

A. Scoping – RTS/EQs/proposal/scope/vision/deliverables/milestones

1. How long did it take to scope out the research? How many meetings did it take?
2. Could you tell me about the alignment process in regard to the research scope and direction?
    1) Did the team members add to or change ideas described in the topic statement or proposal?
    2) Once your team defined the scope in the initial phase, did it remain same or change?
    3) Did the team discuss what deliverables they would produce in the scoping phase? Were there any critical issues?
3. Was the scope suitably defined to effectively address the research topic/question, and objectives? Moreover, was it realistic for the expected research timeframe?
4. In the initial scoping phase, did the team do background studies, such as literature review or reading related CII publications? In some teams, industry

members present their company practices that are relevant to the topics to the team during this phase. Did your team do that?

1) If so, what do you think are some benefits and/or the importance of such background studies?

B. Data collection, analysis and validation

1. Could you tell me about the data collection and analysis process? Do you think it was effective with respect to supporting the research?
2. What were the data collection methods?
    1) How much time did the team spend for data collection?
    2) What was the most difficult part or greatest challenge in the data collection process?
    3) Could you explain any efforts that worked well or did not work so well? What were the reasons for this?
3. What were the validation methods for the data analysis and findings?
4. Could you describe the industry members' roles in regard to data collection and analysis? For example, direct/indirect data collection, facilitating data collection, reviewing results, and such.
    1) What kinds of reviews or feedback did the industry members provide? If you remember any good examples, please share them with me.
    2) Did the team receive feedback from the industry, for example, CII member companies or other industry experts in regard to the research findings? If so, what was the feedback? In what way did the feedback add value to research process and findings?

III. Team Dynamics

A. Team organization

1. Did the team have sub-teams or sub-committees?
    1) Was this approach designed from the beginning or was it ad-hoc?
    2) What tasks did those sub- groups have?
    3) Do you think that the sub-team approach was effective? If not, why?

2. Did you establish expectations about the performance of individual team members? Could you give a specific example or two?
3. Could you give an idea about the makeup of the team, in terms of previous research experience, technical expertise and background, industry experience, age, or gender? Do you think this composition influenced the quality of research?

B. Team participation

Could you tell me about the overall participation of the team throughout the research process?

1. How were team attrition and meeting attendance?
2. What do you think about the member commitment and engagement?
3. What do you think some important factors to industry participation, commitment and engagement of this team were?
4. What did the chairs or PIs do to keep the team members continuously committed?

C. Leadership – chairs, PIs

1. How would you describe the leadership of the team? Was it industry-led or academic-led, or a combination of both? What were the leadership styles of the chairs and PIs?
2. What were the main roles and responsibilities of the PIs and chairs?
    1) Did academic leadership and industry leadership have separate roles and responsibilities?
    2) What do you think were the main differences between the PI and Chairs of the team in terms of leadership?
3. Did the team have a separate moderator or facilitator for meetings or did the chairs or PIs play that role? If so, how do you feel about their work in this regard?
4. On a CII research team, there are two co-chairs, one from the owners and one from the contractors, to keep the balance between owner and contractor interests and perspectives. This practice is also done in order to share the risk

and burden of having a single chair. Do you think it worked well for your team? Did the team experience any issue or problem with the industry leadership (i.e., chairs)?

5. Was there a core group of people who continuously and actively participated in the research process and made major contributions? About how many people made up this group?
6. Since a team consists of various people from different backgrounds, what important skill sets do you think leaders should have on a CII research team?

D. Major alignment and negotiation process

1. Could you tell me about the overall alignment process of the team?
    1) Did the team have a broad gap with respect to perspectives and ideas? How broad was the spectrum?
    2) Could you describe the decision making process when team member had quite different ideas and perspectives? What was the most important factor or role that helped reach an agreement or consensus?
2. Did the team experience any conflicts in regard to personal interests, values, needs, or expectations between members? How would you describe those conflicts?
    1) Were they constructive or destructive to the overall research process?
    2) Can you remember how such conflicts were handled?

E. Academic-industry collaboration

1. How would you describe working with your chairs and the other PI? How would you describe their personal traits?
2. Could you share some benefits with respect to academic-industry collaboration based on your experience with this team or in general?
3. If you think of any prerequisites, considerations, or factors to productive collaboration, it would be great if you could share them.
4. Overall, how would you characterize the relationships among team members?

F. Communications and meetings

1. What were major communication methods? How frequently were the team members informed of research progress status?
2. Who was in charge of organizing meetings, preparing agenda and keeping meeting minutes?
3. What kinds of team building activities or social activities did the team have? Do you think id those activities helped the team to be cohesive or do you think there are other important factors to good team work?

IV. Product Design and Development

A. Product quality

1. How would you characterize the overall quality of the deliverables, including models, tools, techniques, findings, and the recommendations of the publications? How would you assess the deliverables in regard to implementability and value?
2. How would you assess the deliverables in regard to usability, practicality, timing, and relevance to the topic?
3. Have the team receive any feedback on use of products from the industry since the team sunset? What was their feedback?

B. Product development

1. Could you explain the roles and responsibilities of industry members in developing research products (RS/IR/RR)? Were industry members involved in writing up RS or IR?
2. What were the key considerations in developing research products? For example, easy-to use tool or relevancy and applicability.
3. Delivering IR is not strictly required by CII. It is up to the team's decision whether to deliver IR or not. Was it one of main objectives of the team from start or did team deicide to deliver one later on the process?
    1) What was the main driver or motivation to develop IR (tool)?
    2) Do you think your IR is well designed and consistent with the research findings?

3) Were there any difficulties or challenges in developing IR?

4. Were there any innovative or breakthrough ideas incorporated into the products?

Additional Information

V. Lessons Learned

A. What lessons learned could you offer to build upon this experience and help improve the experience and performance of other research teams?
B. What similarities & differences do you consider to be noteworthy between this research team and other research teams that you participated on?
C. What would you do differently if you could do it again?

VI. Research Outcomes

A. What do you think the real contributions of this research to your company and the industry?
B. Please briefly comment on any personal benefits that you or other team members derived from participation on the team.

VII. General Questions about Academic-Industry Collaborative Research

A. Definition of research success

How do you define research success in academic-industry collaborative research?

1. In general, what criteria would you consider to evaluate the success of such research projects?
2. If you think of any other attributes, qualities, and characteristics of a successful research project, please describe them.
3. Based on your research experience, what do you think some of the key success factors maybe?
4. How would you keep the balance between academic rigor and industry practical relevance?

VIII. Recommendations

Please provide and additional recommendations to improve CII Research.

Appendix H: Interview Questions for Industry

Research Team #: _____ Interview Date:

Personal Background

1. Interviewee name: _____
2. Company name: _____
3. Position/title: _____
4. Domain of expertise: _____
5. The number of years in industry: _____
6. The number of years involved with CII: _____

7. CII roles served:
   - Research Committee _____
   - Breakthrough Strategy Committee _____
   - Implementation Strategy Committee _____
   - Professional Development Committee _____
   - Benchmarking and Metrics Committee _____
   - Knowledge Management Committee _____
   - Ad Hoc (special tasks) Committee(s) _____

8. Previous experience with CII research team(s) (research team number or name):
   - _____

9. Research experience other than CII research (research title and year):
   - _____

Research Process

I. Overall Questions

A. Motivation for participation

What was your motivation for participating on this research team?

B. Strengths and weaknesses

1. What were some strengths and weaknesses in regard to the research process of this team? For example, in terms of research methodology research methodology, team dynamics, and product design and development. What was the greatest strength or challenge?

2. If there were any unique aspects or innovative approaches in this team, please explain them.

C. Research phases (forming-storming-norming-performing or initial/planning-execution-sunset)

Could you briefly describe the research phases such as timeframe and key activities?

II. Research Methodology

A. Scoping – RTS/EQs/proposal/scope/vision/deliverables/milestones

1. How long did it take to scope out the research? How many meetings did it take?

2. Could you tell me about the alignment process in regard to the research scope and direction?

    1) Did the team members add to or change ideas described in the topic statement or proposal?

    2) Once your team defined the scope in the initial phase, did it remain same or change?

3) Did the team discuss what deliverables they would produce in the scoping phase? Were there any critical issues?

3. Was the scope suitably defined to effectively address the research topic/question, and objectives? Moreover, was it realistic for the expected research timeframe?

4. In the initial scoping phase, did the team do background studies, such as literature review or reading related CII publications? In some teams, industry members present their company practices that are relevant to the topics to the team during this phase. Did your team do that?

    1) If so, what do you think are some benefits and/or the importance of such background studies?

B. Data collection, analysis and validation

1. How would you describe the data collection and analysis process? Do you think it was effective with respect to supporting the research?

2. What was the most difficult part or greatest challenge in the data collection process?

3. Could you explain any efforts that worked well or did not work so well? What were the reasons for this?

4. Could you describe the industry members' roles in regard to data collection and analysis? For example, direct/indirect data collection, facilitating data collection, reviewing results, and such.

    1) What kinds of reviews or feedback did the industry members provide? If you remember any good examples, please share them with me.

III. Team Dynamics

A. Team organization

5. Did the team have sub-teams or sub-committees?

    1) Was this approach designed from the beginning or was it ad-hoc?

    2) What tasks did those sub- groups have?

    3) Do you think that the sub-team approach was effective? If not, why?

6. Did you, as a co-chair, establish expectations about the performance of individual team members? Could you give a specific example or two?

7. Could you give an idea about the makeup of the team, in terms of previous research experience, technical expertise and background, industry experience, age, or gender? Do you think this composition influenced the quality of research?

B. Team participation

Could you tell me about the overall participation of the team throughout the research process?

1. How were team attrition and meeting attendance?

2. What do you think about the member commitment and engagement?

3. What do you think some important factors to industry participation, commitment and engagement of this team were?

4. What did the chairs or PIs do to keep the team members continuously committed?

5. What would you consider to be most important in regard to keeping the team focused and engaged?

C. Leadership – Chairs, PIs

1. How would you describe the leadership of the team? Was it industry-led or academic-led, or a combination of both?

    1) What were the leadership styles of the chairs and PIs?

2. What were the main roles and responsibilities of the PIs and chairs?

    1) Did academic leadership and industry leadership have separate roles and responsibilities?

    2) What do you think were the main differences between the PI and Chairs of the team in terms of leadership?

3. Did the team have a separate moderator or facilitator for meetings or did the chairs or PIs play that role? If so, how do you feel about their work in this regard?

4. On a CII research team, there are two co-chairs, one from the owners and one from the contractors, to keep the balance between owner and contractor interests and perspectives. This practice is also done in order to share the risk and burden of having a single chair. Do you think it worked well for your team? Did the team experience any issue or problem with the industry leadership (i.e., chairs)?

5. Was there a core group of people who continuously and actively participated in the research process and made major contributions? About how many people made up this group?

6. Since a team consists of various people from different backgrounds, what important skill sets do you think leaders should have on a CII research team?

D. Major alignment and negotiation process

1. Could you tell me about the overall alignment process of the team?

    1) Did the team have a broad gap with respect to perspectives and ideas? How broad was the spectrum?

    2) Could you describe the decision making process when team member had quite different ideas and perspectives? What was the most important factor or role that helped reach an agreement or consensus?

2. Did the team experience any conflicts in regard to personal interests, values, needs, or expectations between members? How would you describe those conflicts?

    1) Were they constructive or destructive to the overall research process?

    2) Can you remember how such conflicts were handled?

E. Academic-industry collaboration

1. How would you describe working with your PIs? How would you describe their personal traits?

2. Could you share some benefits with respect to academic-industry collaboration based on your experience with this team or in general?

3. If you think of any prerequisites, considerations, or factors to productive collaboration, it would be great if you could share them.

4. Overall, how would you characterize the relationships among team members?

F. Communications and meetings

1. What were the major communication methods? How frequently were the team members informed of research's progress?

2. Who was in charge of organizing meetings, preparing agenda and keeping meeting minutes?

3. What kinds of team building activities or social activities did the team have? Do you think such activities helped the team to be cohesive or that there are other important factors that influenced good team work?

IV. Product Design and Development

B. Product quality

1. How would you characterize the overall quality of the deliverables, including models, tools, techniques, findings, and the recommendations of the publications? How would you assess the deliverables in regard to implementability and value?

2. How would you assess the deliverables in regard to usability, practicality, timing, and relevance to the topic?

3. Has the team received any feedback on the use of products from the industry since its sunset? If so, what was their feedback?

C. Product development

1. Could you explain the roles and responsibilities of the industry members in developing the research products (RS/IR/RR)? Were the industry members involved in writing up the RS or IR?

2. What were some key considerations in developing research products? For example, an easy-to use tool, relevancy, or applicability.

3. Delivering an IR/tool is not strictly required by CII. It is the team's decision whether to deliver an IR/tool or not. Was this one of the main objectives of the team from the start or did the team decide to deliver one later in the process?

    1) What was the main driver or motivator to develop an IR?

    2) Do you think your IR is well designed and consistent with the research findings?

    3) Were there any difficulties or challenges in developing your IR?

4. Were there any innovative or breakthrough type of ideas incorporated into the products?

Additional Information

I. Lessons Learned

A. What lessons learned could you share in order to build upon this experience and help improve the experience and performance of other research teams?

B. What similarities & differences do you consider to be noteworthy between this research team and other teams that you have worked on?
C. What would you do differently if you could do this research again?

II. Research Outcomes

A. What do you think the real contributions of this research are to your company and to the industry?
B. Please briefly comment on any personal benefits that you or other team members derived from participation on this team.

III. General Questions about Academic-Industry Collaborative Research

A. Definition of research success

How do you define research success in academic-industry collaborative research?

1. In general, what criteria would you consider to evaluate the success of such research projects?

2. If you think of any other attributes, qualities, and characteristics of a successful research project, please describe them.

3. Based on your research experience, what do you think some of the key success factors maybe?

IV. Recommendations

Please provide and additional recommendations to improve CII Research.

Appendix I: Informed Consent and Confidentiality

Informed Consent and Confidentiality

Title: Key success attributes for academia-industry collaborative construction project management research

Introduction

Thank you for agreeing to participate in this research. This form details the purpose of this research study, a description of the interview questions that you will be asked to, and your rights as a participant. The person performing the research will answer any of your questions. Read the information below and ask any questions you might have before starting an interview.

Purpose of the Study

The purpose of this study is to identify key attributes and factors to the success of academia-industry collaborative research in construction project management and to propose recommendations to improve the collaborative research process.

Your Participation

Your participation in this research study consists of an interview lasting approximately two hours. You will be asked a series of questions regarding your experience of a specific CII research team. You are not required to answer the questions. You may pass on any question that makes you feel uncomfortable. At any time you may notify the researcher that you would like to stop the interview and your participation in the research study. There is no penalty for discontinuing participation.

Your participation is voluntary. You may decide not to participate at all or, if you start the study, you may withdraw at any time. Withdrawal or refusing to participate will not affect your relationship with Construction Industry Institute (CII) anyway.

Benefits and Risks

Your participation will contribute your knowledge and insight to the industry and academia in regard to academia-industry collaborative research. This will benefit current and future academic researchers and industry practitioners who are participating and will participate in construction project management research. There are no foreseeable risks to participating in this study.

Confidentiality

Your interview will be audio recorded, unless otherwise requested by you. Any audio recordings will be stored securely and only the researcher will have access to the

recordings. Recordings will be kept until transcription is complete and then erased. Your name and identifying information will not be associated with any part of the written report of the research. All of your information and interview responses will be kept confidential unless you agree otherwise to the publishing of specific responses. The researcher will not share your individual responses with anyone other than the research supervisor. The data resulting from your participation if used for future research will be aggregated with other data in a manner to protect your confidentiality.

Contact Information

If you have any questions or concerns prior to, during or after your participation, you can contact the researcher **Junghye Son** at (512) 471-1408 or send an email to junghye.son@utexas.edu or her supervisor **Stephen R. Thomas** at (512) 232-3007 or at sthomas@cii.utexas.edu.

Signature

You have been informed about this study's purpose, procedures, possible benefits and risks, and you have received a copy of this form. You have been given the opportunity to ask questions before you sign, and you have been told that you can ask other questions at any time. You voluntarily agree to participate in this study. By signing this form, you are not waiving any of your legal rights.

_____ I agree to be audio recorded.

_____ I do not want to be audio recorded.

_____
Printed Name

_____ _____
Signature Date

As a representative of this study, I have explained the purpose, procedures, benefits, and the risks involved in this research study.

_____
Print Name of Person obtaining consent

_____ _____
Signature of Person obtaining consent Date

Appendix J: Case Data Availability

Data Type		Data Source	Cases										
			Distinguished			Atypical			Established			Special	
			D1	D2	D3	A1	A2	A3	E1	E2	E3	S1	S2
Documents	Team documents	Research Topic Statement (RTS)	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes
		Proposal	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes
		Charter	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes
		Meeting agenda	Yes	Yes	No	No	No	No	No	No	No	Yes	No
		Meeting minutes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes
		Interim Reports	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes
		Team roster	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes
	Research products	Research Summary (RS)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		Implementation Resource (IR)	Yes	No	Yes	No	No	No	Yes	Yes	No	Yes	Yes
		Research Report (RR)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Archival Records	CII surveys	CII Post Research Team Survey	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	No
		Annual Conference Evaluation Survey	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes
	CII records	CII product usage - Hardcopy sales and e-copy downloads numbers	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		CII team meeting attendance records	Yes	Yes	No	No	Yes	Yes	No	No	No	No	No

Appendix K: Example of Color-Coded Analysis

Category Lv. 1	Category Lv. 2	Category Lv. 3	Distinguished			Atypical			Established			Special	
			D1	D2	D3	A1	A2	A3	E1	E2	E3	S1	S2
Research Methodology	Scoping	Scope Change (yes / no)				N/A							
Team Dynamics	Leadership	Strong Chairs											
		Strong PIs											
Product Design & Development	Product Quality	Product Quality											

Category Lv. 1	Category Lv. 2	Category Lv. 3	Case Category	Distinguished	Atypical	Established	Special
			Total Number of Cases	3	3	3	2
Research Methodology	Scoping	Scope Change (yes / no)	Positive	3	2	2	1
			Somewhat				
			Negative			1	1
			Mixed				
Team Dynamics	Leadership	Strong Chairs	Positive	2		3	2
			Somewhat		1		
			Negative	1	1		
			Mixed		1		
		Strong PIs	Positive	3		1	2
			Somewhat		1		
			Negative		1		
			Mixed		1		
Product Design & Development	Product Quality	Product Quality	Positive	3	1	3	2
			Somewhat				
			Negative				
			Mixed		2		

Appendix L: Proposition Validation by Case Category

Category	*Propositions*		Supported?	Data sources	Descriptions	# of cases				Distinguished			Atypical			Established			Special	
Research Methodology						C	A	O	S	D1	D2	D3	A1	A2	A3	E1	E2	E3	S1	S2
Scoping	1	The research scope is well defined and clearly addresses the topic and research question within the time and cost constraints of the study.	partially supported	Interviews	no significant alignment issues around the scope	1	2	2	1	No	Yes	Yes	No	No	Yes	No	Yes	No	No	Yes
					no scope change	3	2	2	1	No	No	No	N/A	No	No	No	Yes	No	No	Yes
Research planning	2	The research plan, methodology, and data collection methods are well designed and thus, properly explored the topic and answered the research question.	supported	Post-RT survey	The topic and research conducted were consistent with what I initially expected.	3	1		1	85%	75%	100%	67%	75%	50%	N/A	N/A	N/A	100%	N/A
				Post-RT survey	The research project plan and schedule were communicated and agreed to before significant work began.	3	1		1	85%	100%	100%	67%	75%	50%	N/A	N/A	N/A	89%	N/A
				Post-RT survey	The team had an appropriate and well organized data collection plan.	3	1		1	92%	75%	100%	33%	75%	50%	N/A	N/A	N/A	89%	N/A
Research methodology model	3	The methodology follows the "Problem/Question → Hypothesis → Data Collection/Analysis→ Validation → Implementation Guidance" model or an appropriate variation of this model.	supported	Research report	had hypothesis	2		1	1	Yes	Yes	No	Yes	No	Yes	No	Yes	No	No	Yes
					did hypothesis testing?	2		1	1	Yes	Yes	N/A	Yes	N/A	Yes	N/A	Yes	N/A	N/A	Yes
					did model validation?	1		2	2	N/A	N/A	Yes	N/A	N/A	N/A	N/A	Yes	Yes	Yes	Yes
					produced implementation guidance?	3		2	2	Yes	Yes	Yes	No	No	No	Yes	Yes	No	Yes	Yes
Appropriate data collection methods	4	The data collection methods are developed to adequately support the research topic and objectives.	supported	Research report	used multiple data collection methods?	2		3	2	Yes	Yes	No	No	No	No	Yes	Yes	Yes	Yes	Yes
				Post-RT survey	The quality of data collected and overall research met my expectations.	3			1	92%	75%	86%	67%	50%	50%	N/A	N/A	N/A	89%	N/A
Data analysis and validation	5	Data and analyses are objective and adequate for the testing and validation of the hypothesis.	supported	Research report	developed hypothesis?	2		1	1	Yes	Yes	No	No	No	No	No	Yes	No	No	Yes
				Post-RT survey	The data collection plan was well executed.	3	1		1	92%	75%	100%	0%	75%	50%	N/A	N/A	N/A	89%	N/A
Innovativeness	6	The research process encourages breakthrough thinking.	partially supported	Interviews	any innovative or unique aspects			1							No		Yes			

Category		*Propositions*	Supported?	Data sources	Descriptions	# of cases				Distinguished			Atypical			Established			Special	
Team Dynamics						C	A	O	S	D1	D2	D3	A1	A2	A3	E1	E2	E3	S1	S2
Alignment	7	The team is well aligned around research objectives and methodology.	partially supported	Interviews	no significant alignment issues around the scope	1	2	2	1	No	Yes	Yes	No	No	Yes	No	Yes	No	No	Yes
				Post-RT survey	The research team was properly aligned throughout the project.	3	1		1	85%	75%	100%	0%	75%	0%	N/A	N/A	N/A	100%	N/A
Participation	8	The team members are committed and actively participated in the research throughout the research process.	supported	Interviews	strong participation & commitment	3	0	1	1	Yes	Yes	Yes	No				Yes			Yes
				meeting rosters						66%	50%	68%	UK	63%	61%	UK	UK	UK	55%	67%
Chair leadership	9	The leadership provided by the team chair(s) inspires member participation and commitment, and is integral to the team's success.	supported	Interviews	strong chair leadership	2	0	3	2	Yes	No	Yes			No	Yes	Yes	Yes	Yes	Yes
				Post-RT survey	The Co-Chairs provided the expected leadership necessary for team success.	2	2		1	100%	38%	100%	67%	100%	75%	N/A	N/A	N/A	100%	N/A
Academic-industry collaboration	10	Academic and industry team members clearly understand their respective roles and responsibilities, and the research effort reflects their synergistic collaboration.	supported	Interviews	strong PI	3	0	1	2	Yes	Yes	Yes	No				Yes		Yes	Yes
				Post-RT survey	The Principal Investigator(s) (team academic(s)) did a good job of structuring and facilitating this research.	3	1		1	100%	88%	100%	0%	75%	25%	N/A	N/A	N/A	100%	N/A
				Post-RT survey	The academic support (development of methodology, facilitation, data analyses, meeting support, etc.) was appropriate and met my expectations.	3	1		1	92%	100%	100%	0%	75%	50%	N/A	N/A	N/A	89%	N/A
Product Design and Development																				
Product quality	11	The research product provides clear and practical guidance for implementation, as appropriate, and is easy to understand and ready to use.	partially supported	Interviews	product quality	3	1	2	2	Yes	Yes	Yes		Yes		Yes		Yes	Yes	Yes
				Post-RT survey	The research project deliverables were most suited to improve performance of CII member companies.	3	2		1	100%	88%	100%	67%	75%	100%	N/A	N/A	N/A	100%	N/A
				Downloads	Product downloads & sales (normalized numbers for last five years)					67	104	33	79	N/A	99	40	78	25	36	62
				Research report	produced implementation guidance?					Yes	Yes	Yes	No	No	No	Yes	Yes	No	Yes	Yes

* Post-RT Survey: counted positive responses (i.e. “Strongly Agree” and “Agree”)

* CII started Post-RT Survey in 2007, and, therefore, the survey data are not available for the Old cases.

* The Case D2 has not conducted Post-RT Survey.

* The product downloads and sales numbers were counted for last five years when the research products of the recent cases became available. The numbers were normalized by the number of products that each case produced and by the number of years that each product has been available for fair comparison between the cases.

Appendix M: Individual Case Description Reports

Appendix M1

Individual Case Description Report

Established Case: E1

Table of Contents

List of Tables

1. Introduction

1.1 CASE INFORMATION

Table M1-1 summarizes the overall information of the case E1.

Case Category	Established		
Project	Project period	4 years	
	Kickoff date		
	Reporting out date		
Industry Chairs	Number of chairs	1 chair	
	Change in chairs	No	
	Previous CII experience	No	
Principal Investigators (PIs)	Number of PIs	2 PIs	
	Change in PIs	No	
	Previous CII experience	No	
Team members	Number of members (excl. academics)	Kickoff: 17	Owner: 10, Contractor: 7
		Report out: 13	Owner: 7, Contractor: 6
	Number of industry members with previous CII research team experience (excl. chairs)	None	
Research Methodology	Research Method	Qualitative	Case studies
	Validation Process		
Products	Products published	Research Summary: 2	
		Implementation Resource: 1	
		Research Report: 4	

Table M1-1: Case Information

1.2 DATA SOURCES

The main data source for this case study was individual interviews with two members of this team. This team is one of three 'Established' cases of which the research projects were conducted more than ten years ago. Therefore, there were not many data sources, such as meeting minutes left for analysis. In addition, since the CII research process at that time was different from the current process which includes developing and/or submitting research topic statement, proposal, charter, and interim, these documents are not available for analysis either. The two team members who were interviewed were the two PIs of this team. No industry member was interviewed due to a difficulty of contacting industry team members since more than twenty years had passed.

Each interview was conducted on a one-to-one basis at a different time and place. Interview durations ranged from approximately one hour to one and a half hours. The dialogue of one interview was digitally voice-recorded upon the written consent of the interviewee. For the other interview, notes were taken by the interviewer during the interview because the interviewee declined to be recorded. Since this research was conducted more than 10 years ago, it should be noted that the interviewees' recollection might not be accurate, which the interviewees themselves mentioned when the interviews started. It should also be acknowledged that there are limited data sources including the industry perspective to this research case that can corroborate the comments of the interviewees.

The data sources and the detail availability for analysis are summarized in Table M1-2. The available data sources, interviews, research products, and CII product usage – product hardcopy sales and e-copy downloads numbers – were analyzed to investigate this case to ensure data triangulation by multiple data sources. Words, phrases, and sentences in italic font with quotation marks hereafter indicate direct quotes either from the interview responses or documentation data.

Data Type	Data Source		Available and used for analysis
Interview	2 interviews	2 academics	Yes
Documentation	Team documents (retrieved from CII SharePoint)	Research Topic Statement	No
		Proposal	No
		Charter	No
		Meeting agenda	No
		Meeting minutes	No
		Interim reports	No
		Team roster	No
	Research products	Research Summary	Yes
		Implementation Resource	Yes
		Research Report	Yes
Archival Records	CII surveys	CII Post Research Team Survey	No
		Annual Conference Evaluation Survey	No
	CII records	CII product usage - Hardcopy sales and e-copy downloads numbers	Yes
		CII team meeting attendance records	No

Table M1-2: Data Sources

2. Case Analysis

2.1 CASE INFORMATION

This team started with 17 industry members and 2 Principal Investigators (PIs). Of the 17 industry members, 10 were from the owner side, and 7 were from the contractor side. When the team reported out at the end of the 2-year research period, the final members were 2 PIs and 13 industry members of which 7 were owner members and 6 were contractor members as listed on the research summary of this team. The team had

only one industry chair, and did not experience leadership change either from the industry side or from the academic side.

The project period of this team was 4 calendar years according to the CII website, which is almost twice as that of a typical research team under the current CII research process. During this 4-year period, the team produced 7 research products consisting of 2 research summaries, 1 implementation resource, and 4 research reports. The team produced these products one by one as the research progressed rather than delivering all products when they closed out. Each PI of this team delivered 2 research reports, and each of these 4 research reports represents different aspects of the research topic, and the work scope was split by the 2 PIs, which was confirmed by the interviewees.

2.2 STRENGTHS AND WEAKNESSES

Table M1-3 includes key responses of the interviewees to the question about strengths, weaknesses and/or challenges, and unique aspects of this team.

Question Category	Interviewee A (Academic – PI 1)	Interviewee B (Academic – PI 2)
Strengths	• Diverse backgrounds of industry members. • Leadership of the industry chair.	• Two academics from different universities. • We had a good, capable chairman.
Weaknesses / Challenges	• Not that I can think of. It was good experience for everybody.	• This was the first experience to everybody. Therefore, there were trials and errors.
Uniqueness	• Industry people really had very active intellectual involvement.	

Table M1-3: Strengths and Weaknesses – Interviews

The two interviewees commonly perceived the industry chair as one of the strengths of this team. Besides this, Interviewee A regarded *"diverse backgrounds"* and *"experience in different segments of the industry"* of the industry members as strengths, and Interviewee B viewed having two PIs from different universities as an advantage of this team. In terms of weakness and/or challenges, Interviewee A did not think that the team had any weaknesses or challenges, saying *"We had the access we needed, we had resources that we needed,* [the chair] *was a very demanding leader, and the team*

respected that and responded to his leadership. I don't think so [the team had weaknesses or challenges]. *Not that I can think of."* Interviewee B noted that *"there were trials and errors"* because *"no one had done* (CII) *research before"* and it *"was the first experience for everybody"*. In terms of uniqueness of this team, Interviewee A noted the active involvement of the industry members.

"I think one of the key differences that made [this team] *as effective as it was was that the industry* [participants] *were to me much more involved than some of the other teams. …..I think everybody who was involved participated and felt a lot of satisfaction out of what they did."*

2.3 RESEARCH METHODOLOGY

Key comments from the interviewees in regard to research methodology are listed in Table M1-4.

Question Category	Interviewee A (Academic – PI 1)	Interviewee B (Academic – PI 2)
Research Schedule	• I think we spend about a year on each of the two phases.	• It was a three year project [from the beginning].
Scoping Phase	• The charge to the committee [team] was pretty broad.	• Not a lot of definitions about [the topic]. We had to start from scratch. • The two academics split up by project.
Alignment around the Scope	• It (charter) was more like one page, one sentence.	• Alignment – 6 to 9 months. • We had no proposal. I don't recall that we had a charter.
Industry Member Background Studies	• There were a lot of good industry presentations [of their company cases).	• They gave presentations about the use of [the topic] at their companies.
Data Collection - Industry Roles	• The industry members made arrangements for case studies.	• Mainly provided projects and contact points for site visits.

Table M1-4: Research Methodology – Interviews

2.3.1 Scoping

For the alignment period, Interviewee B roughly guessed that it took the team six to nine months. He recalled that the research was a three-year project from the beginning. Interviewee A mentioned that the project consisted of two phases and team spent about a year on each of the two phases of the project. According to the CII website, this research team spent four calendar years.

Interviewee A recalled that the requirement from CII to the team was *"pretty broad"* in relation to the topic. He said that *"the most important part of further definition or alignment was the idea of the* [topic] *concepts"*, which was not *"anticipated"*. He recollected that it was the chair's idea to explore the topic concepts in detail. Interviewee B made a similar comment in regard to the research scope that there were not many definitions regarding the topic when they started the research, and, therefore, the team had to *"start from scratch"*. In terms of the scope alignment, Interviewee B recalled that the team first worked on the definitions of the topic, and those definitions that were agreed by the team became the basis of the team alignment around the scope and the research direction.

When asked if the team had any proposal or charter at the beginning, neither interviewee recalled that they developed a formal proposal or charter as CII research teams currently do. Interviewee A recalled that they had a cost proposal rather than a *"proposal about a specific work plan"*. The interviewee also said that the team had a charter, but *"it was more like one page, one sentence"* which was *"very, very brief"*. Interviewee B said that the research scope was unstructured by design, and he did not recollect that the team developed a formal scope definition document.

The research was comprised of two phases and *"the two academics split up* [the research project] *by* [general construction] *project phase"*. According to the 4 research reports, the first phase focused on exploring opportunities of the research topic in a project planning phase. The second research phase was to investigate the research topic in a project execution phase ranging from engineering and procurement to field operations. Each academic produced 2 research reports, and each research report addressed each of the 4 project phases.

When asked if the team defined the research methodology and deliverables in the initial phase, Interviewee A responded positively and further commented as quoted below.

> *"Yes, there were further definitions of both. One of the early activities was to decide about the deliverables and the form of the report versus summary booklet, and, again, how each would address the* [topic]*."*

This interviewee said that he did not recall *"a lot of discussions about alternate methodologies"* once the team *"decided where we* [the team] *wanted to go"*, then *"it was*

pretty clear" what research methodology the team would choose including data collection methods and sources. Consequently, he said that he did not think the team spent *"a lot of time figuring out alternate approaches"*. He also commented that the team focused on the concept of the research topic, and, thus, the research methodology was focused on the concept accordingly.

When asked if industry members did any background studies during the initial phase, both interviewees answered that the industry members gave presentations of their companies in relation to the research topic although literature review was conducted by the academics. Interviewee A provided more details about this as quoted below.

> *"They* [industry members] *thought that it was researcher's responsibility to review the backgrounds and summarize it, and draft a portion of reports to summarize the aspects of literature. They weren't involved in that. But, many of them, many companies presented their approaches to* [the research topic]. *…… there were a lot of those, a lot of good industry presentations."*

Interviewee A further commented that these industry member presentations of their company cases helped the research as well.

"….. Some cases, we just reviewed what they [team members] *reported as examples and data usually related to a particular* [topic] *concept. …… Those kinds of examples* [provided by the team members about their company cases*] were very helpful."*

2.3.2 Data collection

The research approach that this team used was case studies, and the main data collection method was interviews. According to the research report of this team, the team first conducted a survey *"to identify companies"* and *"candidate projects for investigation"*. Then, *"along with input from"* the team, construction projects for case study interviews were selected based on the team's selection criteria. Then, an interview guide was prepared after conducting literature review.

The team interviewed mostly project personnel ranging from project manager to field engineers. In addition to the interviews, the PIs of this team collected and analyzed relevant project document data. Each of the 4 research report addressed different topic areas, and, therefore, the PIs conducted separate case studies. For instance, research report 1 says that *"59 individuals"* from *"14 projects"* were interviewed whereas research report 2 presents that *"83 individuals"* from *"16 different organizations"* were interviewed.

Interviewee A recalled that they did "pretty extensive interviews". He said that they *"always tried to talk to multiple people on a particular project"* and *"used multiple*

types of data sources and backgrounds of people supplying the data" to ensure validity checking of data. According to this interviewee, the data analysis approach was *"cross-case studies"* from which *"overall conclusions"* was drawn. When asked about the industry member involvement in the data collection process, both interviewees responded that the industry members *"made arrangements for case studies"* such as providing *"projects and contact points for site visits"*. Interviewee A additionally mentioned that *"usually, not always, usually there was at least one industry guy was with"* the academics when doing interviews.

2.4 TEAM DYNAMICS

2.4.1 Team participation

Key comments from the interviewees in regard to team participation are presented in Table M1-5.

Question Category	Interviewee A (Academic – PI 1)	Interviewee B (Academic – PI 2)
Team Composition	• People from project level. • Specific relevant experience about [the topic].	• It was a good mix.
Core Group / Participation	• Everybody was involved.	• Probably 2/3 of the team.
Factors for Participation & Commitment	• Challenging people to be engaged and to think really hard about their experience.	
Subgroups - Effectiveness	• [The chair] purposely didn't want us [the team] to break down. • He [the chair] wanted everybody's input.	• Do not recall we [the team] had subcommittees.

Table M1-5: Team Participation – Interviews

The interviewees generally perceived that the team had *"a good mix"* of people. Interviewee A characterized the team members as *"project level"* people from *"very different sizes of projects"*. The following question to this interviewee was how the team members were staffed because the CII research process at the time was different from the current one. Interviewee A responded that CII initially asked for *"interests"* in the research topic, and the team then received *"a pretty good list"* of candidate members. He

said that it was *"a pretty big list to choose* [members] *from"*, and the industry chair was looking for people with *"specific relevant experience about* [the research topic]*"* rather than *"general management"* experience.

In regard to core people, Interviewee A responded that every member was involved while Interviewee B answered that two-thirds of the team were core people. As discussed earlier, there were 17 original members of whom 4 are listed as 'Past Members' in both of their research summaries. Interviewee A particularly emphasized the high level of involvement of the industry members throughout the interview. Interviewee A perceived that the industry chair of this team was a major factor to the high involvement of the team members. He said that that the chair *"didn't want any members who had that 'review attitude'"* and the chair *"wanted participants and active input"*. Interviewee A especially noted the *"intellectual involvement"* of the industry members.

> *"I think the thing that was so different* [from other teams] *was, I guess you would call it a part of methodology, industry people really had very active intellectual involvement..…. [T*he chair] *said "No, we are not going to just sit back and review what the academics found. We want you to think about your experience in view of a lot of tasks and a lot of approaches, we want you to really come up with the insights not just review and comment on things the researchers have done"".*

One example of industry involvement provided by Interviewee A was the process of developing one of the two research summaries. He said that *"everybody was assigned various sections"* of that research summary and *"people would take a lead on a particular concept or some element of describing backgrounds or describing project examples related to the concept"* when the whole team reviewed what each other did.

> *"…..… And then so they* [industry team members] *would prepare the draft, try to distribute it* [draft] *before the meeting, and then, everybody would come up with a lot of comments. There was a lot of pretty intense discussion…..… People became champions on their particular concepts and had to defend them, and there was no being nice or anything like that. It was a very constructive and positive environment, but just a lot of challenging saying "We really want to come up with something that is useful for the industry. We want to make it the very best quality that we can." So, that was a very consistent approach about challenging people to be engaged and to think really hard about their experience and step back. I think, in the end, I think most people said that was one of the most rewarding parts of their involvement* [in the research] *because they were forced either by their own thinking or by somebody else's thinking to challenge their thinking. They were forced to think about* [the topic] *in a very different way."*

When asked if that approach was designed or planned from the beginning, Interviewee A recalled that *"it was* [the chair's] *plan right from the start"* and *"it was his vision of a way"* by which the team *"could have the best project"*. Further, this interviewee mentioned that the chair challenged people to *"do a lot of hard thinking"*.

> *"…… And, I recall it, he* [the chair] *sort of challenged people, saying "That doesn't fit the way you want to work here. If you're much more comfortable reviewing somebody else's work and commenting at various levels, then maybe you are not a good fit for this team because we are going to all do a lot of hard thinking and we are going to all really scrub these ideas from everybody else to make sure that they really are valid and meet our goals"".*

In terms of a subgroup approach, both interviewees did not recollect that the team had any formal subgroups or sub-teams during the research process. Interviewee B recollected that discussions during the team meetings were done as a whole group. Interviewee B noted that the team had *"divisions"* rather than subgroups. According to him, the team had *"two main divisions"* as the research consisted of two phases. He said that it was not formal, but that *"division"* was more dependent on individual experience and expertise as well as industry types, such as building or industrial. Interviewee A emphasized that *"there wasn't anything rigid about it"* and it was not a *"rigid committee structure"*. He further elaborated that it was because the chair did not want to break down the team into smaller groups and the chair *"wanted everybody's input"*.

> "[The chair] *purposely didn't want us to break down, say for example, in our meetings one group go off and discuss one set of concepts and another. He wanted everybody's input. He wanted everybody to think really hard about every part of it even if they didn't have direct experience in that area. He didn't like the idea of breaking down the committee. He wanted drafts prepared by individuals before the meetings, but he wanted everybody to weigh into possible concepts."*

2.4.2 Leadership

Table M1-6 presents key comments from the interviewees in regard to leadership.

Question Category	Interviewee A (Academic – PI 1)	Interviewee B (Academic – PI 2)
Leadership	• [The chair's] leadership style was very clear right from the start.	• Industry-led.
Chair	• Highly respected by the team members. • He wanted participation, he wanted input.	• Good chairman. • He had a right balance between influence, which means control, and freedom, which means research freedom.
Leadership Roles & Responsibilities	• We [leaders] talked some about the, particularly, plans for future meetings.	

Table M1-6: Team Leadership – Interviews

Interviewees B regarded the leadership of this team as "*industry-led*". He described the chair as *"a good chairman"* with a *"right balance between influence, which means control, and freedom, which means research freedom"*. He also recalled that the chair *"knew the time to listen and the time to decide and take actions"*. Interviewee A commented that the chair was *"highly respected by the team members"* for his background and ability.

> *"He* [The chair] *wasn't a table pounding yelling guy because he didn't need to be. He wanted participation, [and] he wanted input. He didn't want anybody to sit back and just kind of take it all in and not express their opinions. When it came to time to make a decision, he never had any problem. That was just his background and the way of his doing."*

Interviewee A added that the chair's *"leadership style was very clear right from the start"*, and, thus, *"if people didn't think they could work well in that environment, then they just didn't join"*.

When asked about the roles and responsibilities of the chair and the PIs and if there were any differences between them, Interviewee A first commented that the academic group including the PIs and graduate research assistants *"really didn't have a problem working within that framework* [the research team environment]". That being said, he added that industry people and academics had a *"different background"* and a *"different point of departure"*. He further clarified that the industry members were focused on the research outcomes while the academics and graduate students were more concentrated on the research side, for instance, making sure "*that data quality and validity matched kind of another set of criteria* [academic criteria]*"*.

> *"The PIs had the same goals and were in general aligned with the same plans and methods that the research team suggested.* [The PIs] *May have imposed to make sure that data could support a different use and different application with respect to enhancing knowledge from a particularly defined point of departure……the research team wasn't really that concerned about that. That's the main difference I can think of."*

Interviewee B provided his perspective on the roles and responsibilities of the industry leaders and academic leaders in general. He viewed it as depending on the chair. However, he added that a team relied on the academics in most cases, probably 70% to 80% of teams even though an ideal situation was a joint effort. He noted that chairs were more responsible for team performance saying *"If a team flounders, it is the responsibility of chairs. Chairs make sure things happen and they are accountable to the team"*. This interviewee was asked about the CII's approach of having two chairs, each from the owner side and the contractor side, for one team to provide a balance between owner perspective and contractor perspective. His answer to this question was that it did not really matter. He said *"One is dominating anyway. Having two chairs is good from the perspective of having backup. However, it does not really matter. Not significant."*

> According to the interviewees, the two PIs had not worked together before this team, and they were *"selected independently"* and *"matched"* by CII for this research project. Interviewee A said that *"both were interested in the team"*, and *"both had some background* [on the topic]". He added that there was not *"any joint effort of collaboration before the team was organized"*. He commented that the two PIs *"had good communications and coordination at a PI level"*.

2.4.3 Team communications

Key comments from interviews in regard to team communication are listed in Table M1-7.

Question Category	Interviewee A (Academic – PI 1)	Interviewee B (Academic – PI 2)
Conflicts/Team Relationship	• I don't think there was any interpersonal differences, any problems on the team.	• Very informal and appropriate.
Alignment Process	• We [The team] had strong agreement because we'd been through a lot of alternatives and we had tested candidate concepts in many ways.	
Team Meetings	• I think we [the team] met on average about every six weeks. • I am not sure that we [the team] did much in terms of [meeting] minutes. • [The chair] set the agenda. • Almost every meeting [the chair] had something drafted some kind of document.	• Mostly, the chair led meetings and discussions, and sometimes the academics did.
Team Communications	• It was a pretty much paper-based operation. Phone calls.	
GRA	• [The team] had two really experienced students with industry experience and backgrounds. • They [the graduate students] pretty much operated independently.	

Table M1-7: Team Communications – Interviews

When asked about the team alignment process, interviewee A responded that the team had *"strong agreement"* since the team explored a number of options regarding the topic.

> *"Everybody really had shared goals and shared understanding and very different backgrounds and different way of doing things, but ultimately when it came down to making choices about things like concepts, I think we had strong agreement because we'd been through a lot of alternatives and we had tested candidate concepts in many ways."*

Interviewee A said that the team *"met on average about every six weeks"*. According to this interviewee, the chair and the PIs communicated with each other and talked about topics for discussion and meeting plans.

> "*We talked some about, particularly I think, plans for future meetings. ….…* [The chair] *would want to know how far along we were, what topics we thought we could bring for some interesting points to discuss to the meeting when he was putting together the agenda, of course, and comments on draft reports."*

Interviewee A mentioned that the meeting agenda was set by the chair, but he did not recall that the team kept the meeting minutes. He further commented that the team had something delivered at the end of every meeting.

> "*I am not sure that we did much in terms of minutes. [The chair] set the agenda. We scheduled a meeting at the prior meeting to get a best time for people to meet, and* [the chair] *set the agenda. I think really the work product of the meeting, almost every meeting [he] had something drafted some kind of documents."*

In regard to the graduate research assistants, he said that he had "two really experienced students with industry experience and background".

> "*They* [graduate students] *did most of the travels for data collection. They got to industry people really well, came to most of the taskforce meetings, and they were really active members of the taskforce team. ….…They were just capable of independent operation. They presented and defended a lot of their findings at the meetings."*

2.5 PRODUCT DESIGN AND DEVELOPMENT

Key comments from the interviewees and Post RT Survey respondents in regard to research products are presented in Table M1-8.

Question Category	Interviewee A (Academic – PI 1)	Interviewee B (Academic – PI 2)
Product Development	• The team went through many drafts, many rewrites. • We [The team] very strongly avoided the term 'checklist'.	
Key Considerations	• We [The team] were very focused on content and usability of the products.	
Product Quality	• I can't think of any topics that I thought should have been included and were not, or areas we thought, uh, inadequately described or overly described.	• Very good. Won a national award and [are] still popular.
Team Communications	• Paper-based operation. Phone calls.	
Feedback	• As I recall, particularly we [the team] got more feedback from the building contractors. • We [The PIs] did not get that [the research] published as much as I would've liked.	

Table M1-8: Research Products – Interviews

Interviewee A noted that the team *"went through many, many drafts, many rewrites"* trying to deliver easier and useful product for the users.

> *"The team went through many, many drafts, many rewrites. Lots of times we studied things that were much too detail and much too complicated. That kind of obscured the concept and made it difficult for the readers. I think we worked very hard on the content and usability of the product. …… I think that effort paid off."*

Interviewee A later made some comments about what the team focused on when developing the products when asked about the contributions of the research. He mentioned that the team *"very strongly avoided the term 'checklist'* [type of research products]" because the team *"thought people would blindly apply that"*. He further commented that it was to *"stimulate people to think about applications"* in association

with the topic. He described that their products are *"not a cook book about how to do it but intellectually engaging enough that people are willing to take next steps"*.

When asked about key considerations in developing the research products, Interviewee A listed a number of considerations including *"clarity, concept, understanding, usability, practicality, timing, and relevance"*. He, then, added that the team was "very focused on content and usability of the products". In terms of product quality, Interviewee B viewed it as *"very good"* and *"a solid guide to"* the topic. He added that the products are *"not overly prescriptive"* and *"not heavily tool-focused"*. Interviewee A made a similar comment as quoted below.

> *"I can't think of any topics that I thought or* [his academic*] team thought should've been included and weren't, or areas* [they] *thought, uh, inadequately described or overly described"*.

He further commented that it "was an early CII product, and in some aspect, good or bad, that tone set the level of expectation", and, therefore, "that responsibility was pretty clearly felt" among the team.

The hardcopy sales and e-copy downloads of all products of this team ranked top ten most downloaded CII research teams from 1989 to 2010. This ranking is based on the product sales and downloads that are normalized by the publication year of individual products. The first research summary produced by this team is continuously being downloaded by CII member companies, being ranked among top 50 most downloaded individual CII products in the year of 2011. This first research summary is one of five products, of which research projects were conducted more than 20 years ago, which were ranked among top 50 most downloaded individual CII products in the year of 2011.

APPENDIX M2

INDIVIDUAL CASE DESCRIPTION REPORT

ESTABLISHED CASE: E2

Table of Contents

List of Tables

1. Introduction

1.1 CASE INFORMATION

Table M2-1 summarizes the overall information of the case E2.

Case Category	Established		
Project	Project period	3 years	About 40 months
	Kickoff date	March	
Industry Chairs	Number of chairs	One chair	
	Change in chairs	No	
	Previous CII experience	No	
Principal Investigators (PIs)	Number of PIs	One PI	(2 graduate research assistants)
	Change in PIs	No	
	Previous CII experience	Yes	
Team members	Number of members (excl. academics)	Kickoff: 17	Owner: 9, Contractor: 8
		Report out: 12	Owner: 6, Contractor: 6
	Number of industry members with previous CII research team experience (excl. chairs)	None	
Research Methodology	Research Method	Qualitative	Interviews, workshops, survey
	Validation Process		
Products	Products published	Research Summary: 1	
		Implementation Resource: 2	
		Research Report: 2	

Table M2-1: Case Information

1.2 DATA SOURCES

The main data source for this case study was individual interviews with two members of this team. This team is one of three 'Established' cases of which the research

projects were conducted more than ten years ago. Therefore, there are not many data sources, such as meeting minutes left for analysis. In addition, since the CII research process at that time was different from the current process which includes developing and/or submitting research topic statement, proposal, charter, and interim, these documents were not available for analysis either. The two team members who were interviewed were the PI and an industry member whose role was a facilitator of this team.

Each interview was conducted on a one-to-one basis at a different time and place. The duration of both interviews was approximately one hour. The dialogues of both interviews were digitally voice-recorded with the written consent of the interviewees. Since this case was conducted more than ten years ago, it should be noted that the interviewees' recollection might provide less detail. It should also be acknowledged that there are limited data sources that can corroborate the comments of the interviewees.

The data sources and the detail availability for analysis are summarized in Table M2-2. The available data sources, interviews, research products, and CII product usage – product hardcopy sales and e-copy downloads numbers – were analyzed to investigate the case to ensure triangulation by multiple data sources. Words, phrases, and sentences in italic font with quotation marks hereafter indicate direct quotes either from the interview responses or documentation data.

2. Case Analysis

2.1 CASE OVERVIEW

According to the team roster included in the research summary of this team, the team started with 17 industry members, 1 Principal Investigator (PI) and 2 graduate research assistants. Among these 17 industry members, nine were from the owner side, and eight were from the contractor side. When the team reported out, 12 industry members remained of which 6 were owner members and 6 were contractor members. The team roster shown in the two research reports of this team are slightly different from that of the research summary. Both research reports listed 13 members and 4 past members, while the research summary listed 12 members and 5 past members. One member, listed as a member on the research reports, is listed as 'Past Members' on the research summary. A possible explanation could be that the research summary was published after both research reports were published, and thus, the latest team roster was included in the research summary.

Data Type	Data Source		Available and used for analysis
Interview	2 interviews	- The PI - One industry member	Yes
Documentation	Team documents (retrieved from CII SharePoint)	Research Topic Statement	No
		Proposal	No
		Charter	No
		Meeting agenda	No
		Meeting minutes	No
		Interim Reports	No
		Team roster	No
	Research products	Research Summary	Yes
		Implementation Resource	Yes
		Research Report	Yes
Archival Records	CII surveys	CII Post Research Team Survey	No
		Annual Conference Evaluation Survey	No
	CII records	CII product usage - Hardcopy sales and e-copy downloads numbers	Yes
		CII team meeting attendance records	No

Table M2-2: Data Sources

There was only one industry chair, and the team experienced no leadership change either from the industry side or from the academic side. The PI of this team, one of the interviewees, conducted a CII research project on the same topic area just prior to this team. The facilitator, the other interviewee, was brought onto this team by the chair of this team. The chair of this team did not have any previous CII research experience before this team.

The project period of this team was 3 calendar years according to the CII website. The actual research period was approximately 40 months from the kickoff meeting to report out, and during that research period, the team concurrently conducted two separate research studies. The team had only one chair and one PI, but the team was divided into two groups and each group worked on a different topic. As a result, the team produced 2 implementation resources and 2 research reports, and the research summary has 2

separate sections with each devoted to each topic. This aspect of the team will be further discussed later in this report.

2.2 STRENGTHS AND WEAKNESSES

Table M2-3 includes key responses of the interviewees to the questions about strengths, weaknesses and/or challenges, and unique aspects of this team.

Question Category	Interviewee A (Academic - PI)	Interviewee B (Industry member)
Strengths	• I [PI] had brought in results from the previous study. • Outstanding leadership on the team • Very good mix of people • Excellent graduate students	• [The PI] had a really good base to work from. • [The chair] had passion and burning desire to get a tool. • [Team members] were good. They were also passionate. • Two really good graduate research assistants.
Weaknesses / Challenges	• We [The team] had a lot of internal conflict.	• A lot of conflict.
Uniqueness	• Members were very high level in their organizations. • The subject was one that we had not researched very much or very well. [It was an] opportunity. • [There was] a lot of creativity on the team. • [The team members] were not only engaged in team meetings but they also put resources. • [The team] actually envisioned three tools. [The team members] were thinking long-term.	• Use of a facilitator

Table M2-3: Strengths and Weaknesses – Interviews

The strengths of this team that were commonly mentioned by the interviewees include the PI's knowledge relevant to the topic, industry leadership, good team members, and good graduate research assistants. Interviewee B noted that the PI *"had a really good base to work from"* and the PI was *"very familiar with CII"*.

> *"The strength of the team was, I think two things. Number one was* [the PI], *he had done* [the previous CII research project on the subject], *so he had a really good base to work from."*

Interviewee A, the PI, said that he *"had brought in results from the previous study"* which he thought was strength of the team.

> *"I think the strengths were that we had just finished another research effort….I had been involved in doing the research in the area two or three years leading into it, so I had a unique insight, so that was a strength that I had brought in results from the previous study."*

Industry leadership was also viewed as one of the strengths of the team. Interviewee A commented that the industry chair demonstrated *"outstanding leadership"*. Interviewee B said that the chair had a *"passion and burning desire"* relating to the research topic. Interviewee B added *"I think when you got experience and dedication plus passion, and you put those together, that's pretty powerful, really powerful"*.

Further, both interviewees perceived that the team had good team members. Interviewee A noted that the team members were *"a lot of senior* [industry representatives]*"* who had *"experience"* and *"interest"* in the topic.

> *"It* [The team] *was made up with a lot of senior people with experience who were the leaders in the company. They had the best interests because* [their] *companies sent to them to improve their* [topic related] *processes, so they were there to learn. It was a really very good mix of people."*

Interviewee B mentioned that the team members were *"good"* and *"passionate"* as well. However, he noted that *"too much passion"* of the members caused a lot of conflicts, and the team became *"borderline dysfunctional"*. Nevertheless, he added that if that passion could be controlled and managed, it could turn out *"a lot of energy"*. He perceived that the team had *"passion, conflict, and desire to make difference"*.

> *"……there is nothing wrong with a conflict as long as you can manage it. So, I think passion, conflict, and the desire to make difference,* [with] *all those things combined, we ended up with a really good team. But it was not easy. Not without trouble."*

This conflict issue of the team was mentioned by Interviewee A as well. He recollected that there were *"very strong opinions"* and *"a lot of passion"* in the team. This interviewee had a similar perception as that of Interviewee B. Interviewee A thought that conflicts among the team members might have helped the team.

> *"As far as weaknesses of the team, we had a lot of internal conflict.....I am not sure that was a weakness or not, maybe it was a factor that helped, but there were very strong opinions……. and there was a lot of passion."*

When asked about uniqueness of this team, Interviewee A noted three unique aspects, which are member composition, the research topic, and creativity of the team. First, the team members were in higher positions in their company than most teams. Second, the team had an opportunity to explore a topic which had not been studied much; and third, there was a lot of creativity on the team.

> *"I think there are two or three pieces. One, it was unique in the fact the membership of the team as a whole was very high level in their organizations…… It was unique in the subject that we had not researched very much or very well, so we had an opportunity there…… It was probably unique in that there was a lot of creativity on the team….. The unique circumstances of those teams, though, were that they were under the original system that CII set up for the research environment where a team was on around an idea and they had to come up with a scope of work, schedule, and deliverables, and* [then] *they asked CII for money."*

Interviewee A mentioned two more aspects that he thought were unique later in the interview. One of them was support from the industry members, and the other was a long-term approach to the research. First, he said that *"they* [the team members] *were not only engaged in team meetings but they also put resources into hosting events"*, which he thought *"was pretty unique"* and is not seen *"nearly as much today"*.

The other thing he referred to as unique was that the team *"envisioned three of these tools"*. He said that the team was *"thinking, even then, long-term"* not *"short-term"*. This long-term approach is also described in one of the research report of this team. The research report states developing three versions of a tool as one of research objectives.

2.3 RESEARCH METHODOLOGY

2.3.1 Scoping phase

Key comments from the interviewees in regard to research scoping are listed in Table M2-4.

Question Category	Interviewee A (Academic - PI)	Interviewee B (Industry member)
Scoping Phase	• We had a lot of brainstorming with [the facilitator].	• [The second research topic] was not included in the original scope. It surfaced. We felt that we had to address that.
Alignment around the Scope	• We had some alignment issues.	
Scope Change	• In the old system, the scope was very vague and the team developed the scope. So, once we developed the scope, which took six or eight months, then it didn't change.	
Industry Member Background Studies	• We had 14 companies that provided their [topic related] process maps.	• Each of these individuals brought in their company [topic related practices]. We used them as a basis for developing the scope of work.

Table M2-1: Research Scoping – Interviews

2.3.1.1 Scoping

In regards to research scoping, Interviewees A and B were first asked how the team developed the research scope for the two different topic areas since this team delivered two different research efforts in one topic area within the originally given research timeframe. Interviewee B said that the team *"argued about* [the second topic]". According to Interviewee B, the team felt that they had to address the second topic because it would be one of key conditions necessary for implementing the first topic. He mentioned that the second topic *"was not included in the original scope"* and it *"surfaced"* as the research progressed, which was to *"the surprise"* of the team.

> *"…… I think* [the second topic] *was a big surprise to us. …...we kind of found out that it is really hard to define a scope if your team is* [not achieving the second topic]. *So finally we said we had to address* [the second topic]*."*

Interviewee A said that the team *"had a lot of brainstorming with* [the facilitator]". The team *"divided into two areas"*, and another graduate student was brought in to work on the second topic.

When asked how the team was aligned around the scope, Interviewee A he recalled that the team had some alignment issues, specifically between the chair and Interviewee A himself. Nevertheless, Interviewee A concluded that having that conflict was *"much better"* than having no conflicts because it meant that the team members had been *"engaged and involved"*.

> *"……So we had some alignment issues. But looking back at it, it is much better that they were doing those things than not because* [if] *they had not been so engaged and involved, it would have never happened. So, there were some alignment issues within our team."*

This alignment issue was also mentioned by Interviewee B as one of weaknesses of this team. Interviewee B said that the chair and the PI had *"a lot of conflict"*. He further commented that the reason behind the conflict was that the PI *"was trying to do a standard thing"*, which means the PI tried to follow the standard CII research process, whereas the chair wanted the research results immediately.

Interviewee A commented that it *"took six or eight months"* to develop the scope, and *"it didn't change"*.

2.3.1.2 Industry background studies

In regard to industry background studies during the initial phase of the research process, both interviewees mentioned that the industry team members provided their company processes related to the research topic. Interviewee B said that besides academic's literature review, each team members brought in their company practices relevant to the topic. He further commented that the team had *"a lot of material coming in from the owner side"*, and the team particularly used the processes provided by two owner companies *"as a basis for developing the scope of work"*. Interviewee A said that the team *"had 14 companies that provided their* [topic related] *process maps"*. Among those, they found that one of the owner companies used a *"really good process"*, so the team *"used that as a starter set"*.

2.3.2 Research methodology and data collection

As discussed earlier, this team divided into two sub-teams and each conducted separate research on two different topics. The research methodologies that the team used for two topics, consequently, were different. For the first topic, the research process was first to identify elements to be included in a tool based on literature review, team expertise, and a workshop. Next, they assigned weights to each element in two

workshops, and finally, they developed and validated the tool with sample projects. Since the research clearly stated that the research objective for the first topic was to develop a tool according to the research summary and the research report, the research process focused on developing the tool accordingly. For the second topic, the process consisted of three phases which were *"a set of workshops"*, *"a series of mail surveys and telephone interviews"*, and *"a series of extensive interviews"* to collect data about the second topic.

2.3.2.1 Research topic 1

The first step was to identify tool elements. According to the research summary and research report, the sub-team worked on potential elements from a literature review and *"documentation from fourteen owner and contractor companies"* participating on the team. This initial list of elements was reduced and refined using *"the research team's internal expertise"*. After the team developed descriptions for those elements, the team held a *"separate workshop"* of industry practitioners not on the team to *"fine tune the list of elements and their descriptions"*.

The team then *"hypothesized that all elements are not equally important"*, and, therefore, the team decided to weight those elements through workshops with industry practitioners not on the team. The research summary notes that the workshop approach was selected because the team felt that *"a broad range of industry expertise would provide the best input"* for developing *"credible weights"*. Two workshops were held in two different locations *"to obtain an equitable representation from different geographic regions"*. *"A total of 54 experienced project managers and estimators were invited"* to the two workshops.

The research report indicates the benefits of using workshops to collect data. This *"method was chosen over others"* because *"it provided immediate feedback to the research team"* compared with other methods, such as surveys. In addition, it was interactive since *"representatives from the research team were present to verbally explain the weighting instructions in detail and answer any questions from the workshop participants"*. Thus, the research report concluded that *"the research team felt that the data obtained using this method was of a higher quality"* than using other data collection methods.

The team developed the tool through normalization and statistical analysis of the weights that were obtained from the two workshops. Then, the tool was validated using sample projects. The research summary and research report stated that the tool was tested on actual projects because the weights were *"opinion-based"* even though they were based on the extensive expertise of a number of workshop participants. The team selected 23 projects, of which 13 were from owners and 10 were from contractors, and detailed questionnaires were sent to the companies. The research summary indicates that the tool was tested on *"a total of 40 projects"*. The difference of the numbers of projects used for validation shown in the research summary and in the research report was not explained in

either of the products. The possible explanation could be data from more projects were collected and added since the research summary was published one and half years later than the research report, which may imply that the team had sufficient time to collect more data for tool validation.

2.3.2.2 Research topic 2

The team had not specifically defined developing a tool as a research objective for the second topic. Rather, the research objective was to address critical issues in regard to the topic according to the research summary. The research report for this topic (the second research report) described that the sub-team for this topic established a research hypothesis and developed a conceptual model based on a literature review. Data collection techniques used for this topic were *"brainstorming sessions, workshops, mail surveys, telephone interviews, and personal interviews"*.

The purpose of the brainstorming session of this sub-team was to identify *"issues that may have a significant effect on"* the topic in relation to the first topic since the team perceived that the second topic was critical to the first topic. Next, these issues were validated and ranked through *"three workshops"* with industry practitioners outside the team, which were held in different locations. Workshop participants were asked to complete a written survey following an instruction session, and, then participants were *"divided into smaller breakout teams"* to *"discuss and rank"* the issues *"as a team"* versus individual rank assessment in the previous written survey session.

A total of 20 sample projects were nominated through CII companies based on the criteria that the research team had identified. Followed by a mail survey, which purported to collect project information and points of contact, telephone interviews were conducted. The telephone interview questions consisted of simple rating questions and open-ended questions. In addition, personal interviews with company executives, called *"Best Practice Interviews"*, were conducted *"to identify the current best practices"* in regard to the topic issues.

The results of the three data collection approaches were aggregated and analyzed. Based on the statistical analyses and comparative analyses of each result, the team *"narrowed"* the initial issues to approximately one-sixth based on the magnitude of its impact on project success. One notable aspect is that this second topic research attempted to link to the first topic research. The team included the tool developed from the first topic research as well in the mail survey and sent it to 20 sample projects. Even though statistical analysis of two sets of data collected from those 20 sample projects was not decisive to indicate *"any type of causal relationship between two independent variables"*, the research team believed there was a relationship between the two according to the research report.

2.3.2.3 Interviews

Key comments from the interviewees in regard to the data collection approach are presented in Table M2-5.

Question Category	Interviewee A (Academic - PI)	Interviewee B (Industry member)
Data Collection	• Focus group, industry workshops, tool test and feedback, structured interviews. • Truly, really good effort of how to pull data from multiple sources, to synthesize and analyze the data and to synthesize a framework to make a decision what is most important. • Some advantages of that [industry workshops] is you have a captive audience and you have data at the end.	• We went out on a lot of interviews. • We had workshops.

Table M2-2: Data Collection – Interviews

When Interviewee A was asked how the team developed the research methodology, he described it as *"it evolves"*.

> *"In that project, actually every project I have ever done, you have an idea how you are going to do it, but it evolves. ……In the* [the tool] *development activity, we actually developed these workshops* [when] *industry guys were in. That one* [workshop idea] *was almost on the fly. We were trying to figure out how to do it. It was not going to work to go out to get an individual to talk to because it would take too much time and money. So, we said "Let's do this in workshops.""*

As shown in the above quote from Interviewee A, the workshop idea was not planned but emerged during the team discussion. This interviewee said that he could not tell when the team identified the idea of doing a workshop when he was asked how the team came up with the idea of industry workshop. He said that *"it just happened"* and it *"evolved"*. However, he indicated that he learned from the previous research study that other data collection methods such as a survey method would take a lot of time *"to get the information"*.

> *"I have used it* [workshops] *a lot. Again, I think it was the experience with* [the previous team] *because we had been through that……we had actually* [used] *a randomized survey* [in the previous team]*, and it just took forever to get the information. …… How do you get this in a shortened period of time? The only way was actually trying to have set up meetings where industry could come in. It was one of the things* [ideas] *that we* [the team] *kept throwing. ……why not have team meetings with outsiders? It just kind of evolved."*

Interviewee B mentioned that the team did *"a lot of interviews"* and *"workshops"* which he thought were *"really good"*. He recalled that the team first had workshops to define *"the critical elements"*. He said *"We didn't know what we would end up with. We finally ended up with 72, I think."* Then, in the next step, the team discussed if those *"critical elements"* were all equal, and the team thought that they were not, which led the team to weighting of those elements. He characterized those two steps as *"really good processes that most other teams may not use"*. He then added that that *"workshop approach was for* [the first topic]*"*. He further mentioned that he *"focused more on the* [first topic] *team"*, and, therefore, he said that he was *"not sure exactly what processes they used for* [the second topic]*."*He did not know who brought up the idea of the workshop approach like Interviewee A. He said that it came up during the team discussion. He added that the team felt *"getting everybody in a room"* to collect data would be *"a better way"*.

Interviewee A provided some insights into the research approach for the second topic. He felt strongly about collecting data from multiple sources. This interviewee emphasized that their data collection and analysis process was a *"really good effort"* in that regard.

> *"At the same time, I am a big believer in getting multiple sources of data, and so we had a focus group, we had industry guys coming in workshops, and we had actually run the tool in the companies before and got their feedback."*

Interviewee A regarded immediate data and information collection as advantages of doing industry workshops.

> *"Some advantages of that, one you got a captive audience and you have data at the end."*

Interviewee B made a notable comment about the workshop. He mentioned that the workshops had high turnouts and the workshop participants strongly felt that it was needed to address the topic. He additionally commented that an industry workshop approach was also adopted for a later research team on which he participated, and workshop participants provided *"great energy"*.

> *"I thought it was extremely successful. And what really got me was how many people came. Sixty people or something, just tremendous turnout. When we explained what we were doing, they said "it's about damn time". I mean they were ready to go. And so it was obvious it would be a big hit for everybody."*

2.3.2.4 Industry member involvement

Besides identifying key issues to be further explored during the following data collection steps, such as workshops or interviews, the industry team members were involved in the data collection process by providing contact points for surveys and interviews according to the research report. During the two workshop sessions for the first topic, the team held *"an interactive question and answer period followed the explanation of the weighting instructions"*. The research report further explained that *"the research team fielded questions from the workshop participants and attempted to clarify any confusion regarding the weighting instructions"* during question and answer sessions. It is not clearly stated whether *"the research team"* means only the academics, the PI and the two graduate research assistants. However, inferred from the Interviewee B's comment that *"We had three or four workshops. I didn't go* to *all of them"*, at least a couple of the industry members may have attended the workshops.

The research report for the second topic more clearly presents what activities of the industry members did for data collection. First, the industry members contacted *"representatives from major companies"* for the workshop. Second, *"members of the research team contacted individuals within companies"* and arranged interviews for the *"Best Practice Interviews"*. The research report states that *"the research team sent three to four Representatives"* to those interviews. However, it is not clarified whether these *"Representatives"* from the research team included industry members or not.

When asked about industry member participation in the data collection process, Interviewee A said *"we engaged them when we needed them"*.

> *"…… And the industry, we engaged them when we needed them. So, we would say "we need to hold a workshop in Houston, and we want to have 20 to 25 people there.", so we would have a company* [of a team member] *to say "We will do that. We will come up with meeting agenda." Somebody would volunteer to host meetings, somebody would volunteer to provide refreshments, and then several people would volunteer to contact people in their companies and outside companies. And we went through with our graduate research assistants. So, at the end of the day, we engaged and had the industry work."*

2.4 TEAM DYNAMICS

2.4.1 Team participation and subgroup

Key comments from the interviewees in regard to team participation are included in Table M2-6.

Question Category	Interviewee A (Academic - PI)	Interviewee B (Industry member)
Team Diversity		• The challenge is to get the necessary experience with the mixture of people who think young, if they are not young.
Participation & Commitment	• Team participation overall was very good. • People were very interested and engaged, and improved the process back in their company.	
Factors for Participation & Commitment	• The team commitment fluctuated. • One of the keys is to have a good leader and a strong vision where you want to go. Secondly, we didn't waste time in the meetings. • We also had fun.	• You have to make, everybody believe in the purpose. But even more importantly, their sponsoring company has to believe in this purpose. • Make sure that everybody feels important • Make sure that they can take something back at the end of each meeting that is positive. • Having fun [was also important].
Subgroups	• We would have team breakouts then come back together and report what they were doing.	• There was almost a natural break there. • We just literally went to two different rooms.
Subgroups - Effectiveness		• Break them into groups of four to six people at the most to get real work done.

Table M2-3: Team Participation – Interviews

2.4.1.1 Team participation and commitment

Interviewee B provided his opinions in regard to team composition and diversity. He strongly felt that research teams needed to have diversity in age, race, and gender as well as industry sector. Particularly, he emphasized that a CII research team needed younger people or *"people who think young"*.

> *"…..you get a bunch of old folks in the room, and you don't necessarily get new ideas. So, somehow, the challenge is to get the necessary experience with the mixture of people who think young, if they are not young, at least they think like young people. …..… I mean, you have to get young thinking somehow."*

When this interviewee was asked if there were any new perspectives or innovative ideas during the process, he recalled one instance that the team had with one younger team member.

> *"…..I do know that we had one guy who was pretty young, and you can tell that when we were talking he wasn't there* [did not fully understand the discussions]. *But then, he started asking a lot of probing questions, and that was valuable. Just the fact that he started challenging and asking questions in an attempt to understand. He made us think about what we had just said. It was challenging without being challenged, let's put it that way. It was thinking more about what we were saying."*

In regard to team attrition, Interviewee A said that the team had *"some attrition"*, but he added that *"attrition was not a big problem"*. He perceived team participation as *"very good"*, and he added that he found that *"people were very interested and engaged, and improved the process back in their company"*. According to the research summary and the research report of this team, 5 members out of original 17 members are listed as past members resulting in approximately 30% team attrition.

When asked about factors for team participation and commitment, Interviewee A said that *"the team commitment fluctuated"*. He perceived *"a good leader"* with *"a strong vision"* and productive team meetings as factors for team member commitment.

> *"One of the keys is to have a good leader and a strong vision of where you want to go. Secondly, we didn't waste time in the meetings. These guys wanted to have input into what we were doing. We hadn't had a meeting sitting around and doing nothing. A lot of people look at it, well, this is a fun meeting, I learn, I am doing something, we are not wasting our time. Another tip I used, we also had fun. …..…You go to nice places, and try to do things outside meetings and have fun so you make into a good event for everybody."*

Interviewee B shared a similar perception with Interviewee A regarding the factors for commitment. Interviewee B pointed out that not only team members but also their company *"has to believe in the purpose"*, which he thought more critical. Secondly, Interviewee B emphasized that leaders should make sure that every member *"feels important"* and *"take something back at the end of each meeting that is positive"*. He added that *"having fun"* was a factor for member commitment as well.

> *"You have to make, everybody believe in the purpose. But even more importantly, their sponsoring company has to believe in this purpose, which means, in many cases that means, I think the sponsoring company did believe and send them there. If this person isn't going back and giving them positive input, "Man, look what we did, hey, we are really doing good", if they don't come back with that, "We are really doing a neat thing", they will lose their support on the home team. And, once they lose that, then they will start missing meetings. So, that's pretty crucial there. And, one of the ways you make sure I think is the leadership,* [the PI] *and whoever that chair is, their job is to make sure that everybody feels important, that they are providing input, and make sure that they can take something back at the end of each meeting that is positive. So, that's going to keep your participation more than anything. That and having fun. …… You have to be creative and make sure people have fun. And when they go back, they have a positive story to tell, and they feel like they're important team members. Because if they don't they're gone."*

2.4.1.2 Subgroup

As discussed earlier, a subgroup approach that this team adopted was more than for the purpose of dividing and accomplishing tasks or having discussion in smaller groups. Since the team conducted two separate research studies, the subgroup approach of this team was similar to dividing into two research teams. Interviewee B said that the team did not *"do that as a follow up study"*. Instead, the team *"just separated into subgroups"*. He added that *"it was the PI's style, attack more"*. The motivation to pursue two studies concurrently was, he said, the team *"couldn't have one without the other and didn't want to wait two more years to get the other one"*.

Interviewee A mentioned that the team was *"working breakouts and came back together and compared"* what each team did during the breakouts. He recalled that *"it was a very structured team environment"*. Interviewee B recollected that dividing team into two sub-teams was *"almost a natural break*" because some people were more interested in and strongly felt about one topic and some were in the other topic. He said that the team had two separate meetings in one whole team meeting. It is not known whether the two sub-teams met separately and worked independently from each other in addition to whole team meetings.

Interviewee B provided his opinion on a subgroup approach. He perceived that more work could be accomplished with a small group of people rather than a whole big group because it would be *"very difficult to get ten or fifteen people to do anything"*.

> *"…… if you get three or four people, you can do some work…… So, these little what I call writing workshops are really, really good. That's what we accomplished a majority of our hard work. Now the other work was consensus building, getting input from a bunch of people, and that's important, but you don't get a lot done unless you can get it from small groups. So, small group for work, and bit larger groups for consensus building and agreement and alignment."*

2.4.1 Leadership

Table M2-7 presents key comments from the interviewees in regard to leadership of this team.

2.4.1.1 Industry and academic leadership

Both interviewees described the industry chair of this team as *"strong"*, *"aggressive"*, and *"vocal"*. Interviewee A said that the chair *"really drove the schedule"* and "*wanted things done quickly"*. He also mentioned that the chair *"was willing to put his own company resources into"* the research effort, for instance, the chair brought in the facilitator. He said that the chair even put his *"personal secretary for doing lots of things"* such as taking meeting minutes.

In regard to the academic leadership of this team, Interviewee B first said that the PI of this team was the only one he worked with except academics of a CII standing committee on which he participates. That being said, Interviewee B viewed that the PI has *"done a pretty good job"*. He emphasized that academics on a research team need to listen to industry people and put what they learn into a research process.

He added that he and other members of a later research team worked with the PI on a later teams, and he said that it is *"a really good sign"* when team members wanted to work with a PI on next team.

> "*By the way* [a later research team], *those members went on, three or four of those members went on to serve with* [the PI] *on two more teams. And that's a really good sign there when guys on a team say "I want to be on the next one.""*

Question Category	Interviewee A (Academic - PI)	Interviewee B (Industry member)
Leadership	• Outstanding leadership on the team, [the chair]. • Leadership both owner and contractor sides.	
Chair	• [The chair] was very aggressive. He really drove the schedule. He wanted things done quickly.	
PIs		• That's a really good sign there when guys on a team says I want to be on next one.
Leadership Roles & Responsibilities	• It has to be a partnership. To begin with, [the chair] and I, once we figured out what our roles were and it became a really good partnership. • He prompted resources and he rolled schedule and budget.	
Facilitator		• My job was to really push that team. • My job was to make sure both of them [two topics] were addressed. • My job is to make sure those people get out and get expressed. • Facilitation skills are extremely important.

Table M2-4: Team Leadership – Interviews

When asked about the roles and responsibilities of the industry chair and the PI, Interviewee A characterized their relationship as *"partnership"*. He mentioned that the chair managed the research schedule and budget while he focused on the research process.

"*It has to be a partnership. To begin with,* [the chair] *and I, once we figured out what our roles were, it became a really good partnership.*

He prompted resources and he rolled schedule and budget…… I worked really hard making sure we were doing the research and getting data, and my graduate research students doing things in a right way."

He added that "*the relationship between PI and chairs needs to be respectful, needs to be a partnership"*. Then he provided his opinion in regard to academics on CII research teams in general. He thought that the academics should take strong leadership to achieve academic rigor and sometimes "*step up and take on the leadership role"* when needed.

"*Sometimes there's a leadership void you should step up and take on the leadership role."*

2.4.1.2 Facilitator

This team had a unique feature, a facilitator that most CII research teams do not have. Interviewee B, who acted as a facilitator in this team, provided his experience and perspective as the facilitator. He said that "*probably most unusual thing"* of this team was him "*as a facilitator"* because "*most teams don't have a third-party facilitator"*. He added that he "*was supposed to be a neutral facilitator"*, but "*it was very difficult to do"*. His job in his words was "*to really push"* the team. He further commented that the chair gave him "*a lot of time to push people"* so that he "*was able to call and push"*.

When he was asked how he made the team focused as the facilitator, his answer was "*to encourage discussion"* yet to keep on the discussion on the control as presented below.

"*The real balance is you want to encourage discussion. You want to fuel passion and yet you have to know when to back them off and when to shut them down. And that's almost an art. Because if you're too hard, you shut everything down, and if you let things go, you end up in chaos. So I don't know how to explain that other than facilitation is more art than it is science."*

He said that one important facilitating technique was "*to make sure everybody participates"*, which means encourage quiet people to participate in discussion. He further mentioned that his job was to control "*loud dominators"* and "*bring in"* ideas of other people.

"*When they* [people with strong personalities] *speak, if you have weaker personalities in there, they are going to, you can almost see them kind of shuts down a little bit, you know, which means, they are not going to do anything. So now your next trick is to figure out the way to get those people* [to keep] *quiet and how do I bring these people back in to*

conversation. And that's probably the biggest trick..…… My job is to make sure those people get out and get expressed. That's the main thing. Controlling loud dominators and bring in other ideas of the other people and make sure they are accepted."

He emphasized that facilitation skills were critical for a team to be productive and to have active engagement of team members. According to him, if a team is ruled by dominant people, other members who are not dominant become less and less involved because those less dominant people would *"feel like they are not important"*. Therefore, he concluded that *"the facilitator's job is to make sure everybody on that team feels important"*.

"So there's all kind of facilitating techniques, and there's not many engineering people that are good facilitators. So, I would suggest that facilitation skills is extremely important for teams and you can really make them highly productive and even get a high degree of involvement if you get a good facilitator. If you don't, there's always dominant people on the team, the dominant people will rule, and that's, I am convinced as one reason, why a lot of your team don't follow through, the guys kind of just fade out. They don't feel like they are important to the team. So the facilitator's job is to make sure everybody on that team feels important and gets their saying. That's my summary of a facilitator."

2.4.2 Team communications

Key comments from the interviews in regard to team communication are listed in Table M2-8.

2.4.2.1 Conflicts

As discussed earlier, it appears that the team had a lot of conflicts among the members. Both interviewees recalled that some of conflicts became almost *"fistfights"*. Besides the tension between the chair and the PI, discussed previously, Interviewee B recollected that the chair and one member had conflicts which were very intensive, and they *"almost went to blows, not once, not twice, but several times"*. Interviewee B added that *"they didn't really agree with each other"*. He said *"Conflicts started non-personal and got personal. They hurt the relationship"*. Eventually, the member *"dropped out the team"*, he said. He added that the member *"he should not have been on the team first place"*.

Question Category	Interviewee A (Academic - PI)	Interviewee B (Industry member)
Conflicts / Team Relationship	• We had a lot of internal conflict to the point of, almost [having] a fistfight.	• Conflicts started non-personal and got personal. They hurt the relationship.
Team Meetings	• We had really good minutes. I spent a lot of time with [students] and with [the chair] between meetings to make sure that we were prepared in what we would talk about there. we were actually meeting every four weeks.	

Table M2-5: Team Communications – Interviews

2.4.2.2 Team meetings

Interviewee A perceived that they had a *"very structured team environment"*, and he thought that the chair and the facilitator were the ones *"who set that up"*. The two sub-teams, each working on a different topic, had separate meetings followed by a whole team meeting where they *"would come back together and report what they were doing to the rest of the team"*. He further commented that the team documented what they did very well.

> *"We had really good minutes. We kept those religiously. We actually spent some time at the end of meeting reviewing what we had done and made sure actions were assigned very effectively. He [the chair] just didn't really tolerate not getting things on time, and neither did I. I was very in diligent about having my students prepared meeting every time."*

He had two graduate research assistants, each worked on each topic. Those two graduate assistants and the chair's secretary kept the meeting minutes.

> *"I had one graduate research assistant on one and another graduate research assistant on another meeting. We were going back and forth and seeing. The ideas we were putting together. …..…We documented what we did, and it just evolved. We had no idea we had done anything that would be special until we had a focus group."*

Interviewee A emphasized the importance of meeting preparation in order for academics to *"get as much as"* possible out of industry members during a meeting since industry members would not spend time for research in between meetings.

> *"Very a few industry people are going to write and do things between things. It is not going to happen. We should make sure that meetings themselves were completely scheduled so we could get as much as we could out the teams while they were there. If we were asking them to review things, we needed to be very specific about what we wanted. If we needed them to help us in terms of workshops or hosting a meeting, we were very specific what we wanted."*

Interviewee A also mentioned that people would not continue participating if a meeting was not organized. He said that the chair and the academic group including the graduate research assistants had separate meetings to prepare whole team meetings.

> *"As a PI, you got 12 to 15 people, and they are meeting a day and a half. I have figured it out one time – you are talking about 10,000 or 15,000 dollars, their time, maybe more than that, probably more than that today. And so, if you have a meeting and you are not organized, some people will not come back. I spent a lot of time with graduate research assistants and with the leader [the chair] between meetings to make sure that we were prepared in what we would talk about there. So that's one thing that in every research project I have done at CII. Spend time to be prepared and ready when you have meetings, because it's a big commitment from the industry side….."*

One interesting comment that this interviewee made was about the meeting frequency of this team. Interviewee A said that the team was *"actually meeting every four weeks"* especially during *"the first six months"*. He recalled that *"it was very tight schedule"*, which was *"driven by"* the chair. Eventually, he said, after the team *"developed the scope"*, he *"went to and said there was no time to get things done between meetings"*. He said that *"early on that wasn't a bad strategy"* because the team was developing the scope. He thought that once a team developed the scope, there should be time between meetings to prepare for the next meeting.

> *"…… But early on that wasn't a bad strategy. We were developing the scope. We weren't developing deliverables. Once you get into the deliverable development and research assessment, four weeks is tough. You've got to have time to actually recover from the meeting, live with it, and get ready for the next meeting."*

2.5 PRODUCT DESIGN AND DEVELOPMENT

This team produced one research summary for the two topics, two Implementation Resources, each for each of the two topics, and one research report for each topic. The team also developed a tool for each topic. The two implementation resources, which describe detailed processes to implement the topics and to use the tools, have been revised more than a couple of times since their first publication.

In regard to product development, Interviewee A said that the team was *"to develop tools"* that were *"easy to use and easy to employ"*, which was *"a part of our charter from the very start"*. He said that the team *"came up with an idea, and the idea worked"* for both topics.

The hardcopy sales and e-copy downloads of all products of this team ranked top ten most downloaded CII research teams from 1989 to 2010. This ranking is based on the product sales and downloads that are normalized by the publication year of individual products. The two implementation resources produced by this team are still widely downloaded by CII member companies, being ranked among top 20 most downloaded individual CII products in the year of 2011.

Appendix M3

Individual Case Description Report

Established Case: E3

Table of Contents

List of Tables

1. Introduction

1.1 CASE INFORMATION

Table M3-1 summarizes the overall information of the case E3.

Case Category	Established		
Project	Project period	3 years	
	Kickoff date		
	Reporting out date		
Industry Chairs	Number of chairs	1	
	Change in chairs	No	
	Previous CII experience	No	
Principal Investigators (PIs)	Number of PIs	1	
	Change in PIs	No	
	Previous CII experience	Yes	2 research teams
Team members	Number of members (excl. academics)	Original members: 19	Owner: 9, Contractor: 9, NCCER: 1
		Reporting out: 13	Owner: 8, Contractor: 4, NCCER: 1
	Number of members with previous CII research team experience (excl. chairs)	2	
Research Methodology	Research Method	Quantitative	survey, interview
Products	Products published	Research Summary: 2	
		Implementation Resource: 0	
		Research Report: 2	

Table M3-1: Case Information

1.2 DATA SOURCES

The main data source for this case study was individual interviews with the Principal Investigator (PI) of this team. This team is one of three 'Established' cases of which the research projects were conducted more than ten years ago. Therefore, there are not many data sources, such as meeting minutes left for analysis. In addition, since the CII research process at that time was different from the current process which includes

developing and/or submitting research topic statement, proposal, charter, and interim, these documents were not available for analysis either. The interviewee was the lead PI of this team. No industry member was interviewed due to a difficulty of contacting industry team members.

The interview was conducted in person, and the interview duration was approximately two and a half hours. Dialogue of the interview was digitally voice-recorded upon the written consent of the interviewee. Since this research was conducted more than 10 years ago, it should be noted that the interviewees' recollection might not be accurate. It should also be acknowledged that there are limited data sources that could verify and validate the comments of this interviewee.

The data sources and the detail availability for analysis are summarized in Table M3-2. The available data sources, interviews, research products, and CII product usage – product hardcopy sales and e-copy downloads numbers – were analyzed to investigate the case to ensure triangulation by multiple data sources. Words, phrases, and sentences in italic font with quotation marks hereafter indicate direct quotes either from the interview responses or documentation data.

Data Type	Data Source		Available and used for analysis
Interview	1 interview	1 academic	Yes
Documentation	Team documents (retrieved from CII SharePoint)	Research Topic Statement	No
		Proposal	No
		Charter	No
		Meeting agenda	No
		Meeting minutes	No
		Interim Reports	No
		Team roster	No
	Research products	Research Summary	Yes
		Implementation Resource	No
		Research Report	Yes
Archival Records	CII surveys	CII Post Research Team Survey	No
		Annual Conference Evaluation Survey	No
	CII records	CII product usage - hardcopy sales and e-copy downloads numbers	Yes
		CII team meeting attendance records	No

Table M3-2: Data Sources

2. Case Analysis

2.1 CASE OVERVIEW

This team started with 19 industry members and one PI. Of these 19 industry members, 9 were from the owner side, and 9 were from the contractor side. The remaining one member was from National Center for Construction Education & Research (NCCER). When the team reported out, the team had 13 industry members including 8 owner members, 4 contractor members, and the member from NCCER as listed in the research summary. There was only one industry chair, and the team experienced no leadership change either from the industry side or from the academic side. The project period of this team was three calendar years according to the CII website. The team produced two research summaries and two research reports as deliverables.

2.2 STRENGTHS AND WEAKNESSES

Table M3-3 includes key responses of the interviewee to the question asking about strengths, weaknesses and/or challenges, and unique aspects of this team.

Question Category	Interviewee (Academic – PI)
Strengths	• It began with having a strong leader. • They (team members) were just, real strong members. • They were getting something out of every meeting even though we were just talking about how we were going to do this study. • We established our mission statement. • We had five members that were more or less corporate level people.

Table M3-3: Strengths and Weaknesses

The interviewee first pointed out that the team had strong chair and strong team members when asked about strengths of this team. He characterized the chair of this team as *"a strong leader"* who *"had a real strong interest in this project"*. He then mentioned that the team *"started out as a fairly large group"*. However, after team attrition, the team *"had ten pretty solid people"* who *"were really key people"* and *"strong members"*. He further commented that there was *"a lot of networking going on"* among these key team members. He added that the members *"were getting something out of every meeting"* which he thought made *"a big difference"*.

> *"They were all pretty much on the* [topic related] *side. …..…there was a lot of networking going on. …..… I guess, because they were getting something out of every meeting even though we were just talking about how we were going to do this study. That was really what made a big difference I think. They were getting something out of these meetings even in addition to helping out this research project."*

Another aspect was that the team developed the mission statement in the kickoff meeting. He emphasized that establishing a mission statement was critical to make sure that *"everybody was really on the same page"*.

> *"…..… So the mission is really, it's just a sentence, one sentence. It was a very succinct statement.* [However,] *it's not something that in five minutes we had it. We may have talked about a couple of hours. I think that's really crucial and really important at the outset to make sure that everybody is really on the same page to get what we hope to get out of this study."*

When asked who made that suggestion to develop the mission statement, the interviewee guessed that it was the chair or a person from CII. He further elaborated that he first considered it as *"a silly stuff"*. This interviewee participated on two CII research teams as a PI prior to this team, and, obviously, it was the first time for the interviewee to develop a mission statement. However, ever since, he said that establishing a mission statement had become the first thing that he did when he participated on CII research teams because he strongly felt that establishing a mission statement at the very beginning helped a team to stay on track.

> *"…..… But, whoever brought it up, we embraced that right away. I guess I have to admit first I thought about it, 'That's kind of, maybe a silly stuff. We know what we want to do.' But you really need put the words down. I mean, now, that sort of set the model. Like I have said, I have been on several projects since,* [and] *that's the first thing I've said 'We must do it. We must have a mission statement.' because otherwise you can very easily get steered away. If you agree on it from the beginning, then it's always certain go back to it and say 'Okay, let's make sure that we still on track.'".*

Another strength that the interviewee perceived was having several team members who were in a higher management level position, which he thought helped the team members be *"on an equal basis"* and did not let the chair dominate the team.

> *"…..…we had five members that were more or less corporate level people. Had we not had that, I could see a strong leader that is corporate, everybody else is maybe third tier, I could see that the leader would*

almost dominate, but with the mix we had, that was not the case. Everybody seemed to be kind of on an equal basis, and everybody was letting the leader more or less 'okay, lead the group', but everybody was going to have their saying in the end. So, it worked out well."

2.3 RESEARCH METHODOLOGY

Key comments from the interviewee in regard to research methodology are listed in Table M3-4.

Question Category	Interviewee (Academic – PI)
Scoping Phase	• After the first meeting, we were pretty much in aligned already.
Alignment around the Scope	• No major conflicts. • I think the basic methodology stayed pretty much the same.
Industry Member Background Study	• We didn't give them [team members] tasks.
Deliverables in the Initial Phase	• The deliverables probably weren't thought through very well in the early stages. I think we were thinking more in findings rather than in terms of deliverables.
Data Collection Methods	• Mail survey and interview
Data Collection - Industry Roles	• As a team, really, especially on the questionnaires, helped refine the questions so they were really getting the information we wanted. • The team was also crucial in getting the access to projects. • They were not involved in the analysis itself, but they definitely critically reviewed my analysis.
Feedback on the Interim Findings	• [One of the team members] developed a survey himself, did it within his company, and in our next meeting, reported what he found.

Table M3-4: Research Methodology

When the interview started, the interviewee first provided the background information on how this research project was initiated. According to him, he did *"a little mini-study of about 30 companies"* in regard to one of previous CII research efforts, which had been conducted in a same topic area by a different academic researcher. Based on the findings of his 'mini-study', he said"[I] *discovered that things had really changed quite a bit"*, which motivated him to apply for a follow-up study. One of the two research reports also stated that this research was *"to be an update of and a follow-up study to the"* previous CII study.

2.3.1 Scoping

The interviewee said that the team members *"were pretty much aligned already"* after the first meeting. As discussed in the previous section, the team established the mission statement in the first meeting. The interviewee did not recollect any major conflicts regarding the research scope or objectives even though there were *"differences in opinions"*. When asked if the team members did any background studies or made presentations of their company practices relevant to the topic in the team meetings, he said that the team members did not have individual tasks.

2.3.2 Data collection and analysis

The primary data collection method of this research project was an interview approach with "[topic related] *representatives"* on construction project sites. According to the research report, the team implemented two kinds of data collection methods, which were a *"survey"* of *"large construction firms"* and a *"survey"* of *"large construction projects"*. Both surveys *"followed similar formats"* in terms of the topic areas covered in the questionnaires. The *"large construction projects"* survey includes more detailed questions including project specific questions since that survey was to be conducted through in person interviews. The survey for *"large construction firms"*, which targeted a broader range of respondents, was distributed and replied by mail. The research summary stated that data collected from for the *"large construction firms"* survey as *"additional data.* Accordingly, the research summary focuses mainly on the data analysis and findings of the survey (interviews) of *"large construction projects"*.

The interviewee said that the team *"did the mail survey first"*. He further mentioned that the results of this survey provided *"some good information, but it was too cursory"*, which caused the team to change some of questions.

> *"…… I mailed out surveys to the top 400 construction companies. ……We got some good information, but it was too cursory. But it definitely gave us more of a focus of which way we needed to go. And that caused some of questions in the questionnaire changes as well."*

In terms of the industry involvement in the data collection process, the interviewee mentioned that the industry members helped him (the PI) refine the questionnaire, arranged site visits for the interviews, and reviewed the data analysis that the interviewee prepared.

> *"…… I think the basic methodology stayed pretty much the same. But as a team, really, especially on the questionnaires,* [the industry members] *helped refine the questions so they were really getting the information we wanted. ……The questionnaire changed dramatically because just about every question was altered. And the team looked at those very carefully."*

The research report stated that *"all the projects* [for data collection] *were identified by the research team"*. The interviewee commented that it was *"incredibly helpful"* that the team provided the access to projects. The interviewee added that the industry members were not directly involved in the data analysis process. Rather, the team actively provided input and feedback on the data analyzed, which he thought was critical. The interviewee recollected one instance that showed how the team members *"critically reviewed"* the data analysis that he presented.

> *"…… I remember what I presented was the seven things. Well, we met in Florida, and all of sudden, somebody was saying "Well, aren't these two different?" and somebody said "Well, aren't these two different?" and all of sudden, we ended up nine. So, clearly they weren't just sort of being sponges and just saying 'well, just tell us what the findings are'. They were critically reviewing it, and I think, it turned out really good. If it had been just left up to me, I may have left it at seven, you know. They were not involved in the analysis itself, but they definitely critically reviewed my analysis."*

One notable aspect of the data collection process was that part of the data collection effort was subcontracted to one academic researcher at another university. The research report noted that *"a subcontract was awarded to"* that university *"to facilitate data collection in the western United States"*. This academic conducted *"ten interviews"* out of a total of *"38 interviews"* done for this research. The interviewee perceived that that academic as a *"subcontractor"* rather than a co-PI when asked if that academic was a co-PI.

Another unique instance happened in the middle of the data collection and analysis process. When asked about the industry background studies during the initial phase of the research, the interviewee recollected that one industry members actually implemented one of the preliminary research findings within his company midway through the data collection and analysis process. As a result, his company changed its

practices based on what this member found through his own survey, which the interviewee regarded as impressive.

2.4 TEAM DYNAMICS

Key comments from the interviewee in regard to team dynamics are included in Table M3-5.

Question Category	Interviewee (Academic – PI)
Team Attrition	• We had significant attrition from what we started with.
Core Group / Participation	• The core group was absolutely committed.
Factors for Participation & Commitment	• They wanted something out from this research.
Subgroups	• No subcommittees.
Chair	• He was very strong, very opinionated. • He had opinions, but he always sought input from the team.
Leadership Communication	• We had frequent communications, I would say at least weekly.
Leadership Roles & Responsibilities	• He would take the charge of the meetings, had an agenda prepared, and, usually, that would be in concert with talking with me. • I always feel like I have to constantly remind them of what stages we are going to go through before we report out.
Team Relationship	• There was always a mutual respect.
Conflicts	• Actually only conflict I can think of was when we were doing finalizing this report.
Team Meetings	• We got together every two months. • He (chair) was definitely in control. As a PI, I have never been in control of a meeting.

Table M3-5: Team Dynamics

2.4.1 Team participation and core group

The interviewee commented that the team experienced significant team attrition. He pointed out that the team had about *"ten pretty solid people"*. The team roster in the research summary lists 13 industry team members including one member from NCCER. Since team rosters at the kickoff meeting or during the team process were not available, the initial team members were drawn from the CII database. The CII database listed 19 industry members including one member from NCCER for this team. Therefore, initially the team had 19 members, and 6 members dropped out with an attrition rate of approximately 32%.

The interviewee recollected that the team started with 15 members and ended up with 6 or 7 core people. He added that 5 members participated in only one or two meetings. He then provided a comparison in terms of member participation between this team and another CII research team where he was participating as a PI. He said that his current team had a high level of member participation and low team attrition. He noted that this team had no subgroups while his current team utilized a subgroup approach. He further elaborated that a subgroup approach could be one factor to member participation even though he had a concern of a subgroup approach since there might be a potential that a team would not capture input from everybody on every issue. When asked about factors for member commitment, the interviewee commented that the members *"wanted something out from this research"*.

2.4.2 Leadership

2.4.2.1 Industry leadership

The interviewee characterized the chair as *"very strong"* and *"very opinionated"*. However, he mentioned that the team had also strong members and *"there was always a mutual respect"* among the members, and consequently, the chair did not lead the team to his direction.

> *"…… He* [the chair] *was very strong, very opinionated, but we had about a half of dozen other top level people who basically had their own ideas as well. And so, there was always a mutual respect. Everybody had a healthy respect for everybody else."*

When the interviewee was asked if there was any example that would illustrate the style of the chair, he provided one instance as quoted below.

> *"It seems like the chair, just by the virtue of the being the chair, he would say his view first. And that's why if we would've had all lower tier people, maybe didn't have that mutual respect, it might just have been*

drop there. But since we had such strong people, they all said "I'm thinking this is also a factor." Somebody says "Well, not only that…" you know. He opened a topic, but they didn't let it say it, and say and he doesn't have a final word. He just had a first word. Whereas some of the chairs I have had since then would just sort of "Well, what would you think about that?""

2.4.2.2 Academic leadership

The interviewee provided his perspective regarding a PI of a CII research team. He mentioned about the attitude of a PI and working as a single PI versus working with a co-PI on a CII research team. First, the interviewee emphasized that a PI should not put his or her ego front.

> *"……as a researcher, your ego can't be a big part of the project. I mean, maybe I had twenty* [survey] *questions on one page, they changed maybe twenty of the questions. It's better when the industry side have a look at it. I think that's why you really make sure that you're always viewing your research team as a resource."*

Another aspect was about a co-PI. He said that he did not prefer having a co-PI. This interviewee had participated as a PI on 7 CII research teams by the time of the interview including the team that was close to reporting out. From those 7 teams, he worked as a single PI on 4 teams and worked with other PIs on 3 teams. He acknowledged that having multiple PIs on a single research team was the effort of CII to provide junior researchers with more opportunities to participate in CII research. However, he also noted its downside from his standpoint.

> *"I guess I tend to have a preference for not having a co-PI. I know the rationale for the co-PI to a large extent is for the, at least this is my view, it's for CII who wants to provide a form for which young and inspiring researchers can grow. …… The downside I see is that, for instance, I am a PI of the project now, the industry people that are the research team members don't seem to see the distinction between the PI and the co-PI because I don't run the meetings. Sometimes they lose side of who's really doing the research and who's really, at least on the academic side, driving things."*

He, then shared his experience as a co-PI on a team where a younger researcher was in charge of a leading role. He said that there were some differences in perspectives between the lead-PI and him on that team. He further commented that *"it would be interesting to do an evaluation"* on the cost of having co-PI(s) because in many cases, having a co-PI means *"a parallel budge at both places"*. He noted that some research

topics that might require multiple academics, especially a topic was *"venturing a new ground"*, therefore, having multiple PIs or single PI depended on *"the nature of the topic"*, and *"it also depends on the nature of the individual"*.

2.4.2.3 Leadership roles and responsibilities

The interviewee said that the chair and he *"had frequent communication at least weekly"*, and they knew what each other was doing. He recollected that the chair did *"set the agenda, schedule the meetings, schedule the rooms, have the minutes"* which he described as *"almost duties"* of a chair. In terms of leading the team meetings, the interviewee said that the chair *"was definitely in control"*. He further commented that *"as a PI, I have never been in control of a meeting"*.

> *"……as the PI, as a researcher, I have a healthy respect for the research team. And I realize that they* [industry members] *are playing a tremendous role in the research. So, I definitely try not to push anything through."*

However, the interviewee, as the PI, was the one who managed the research schedule and made sure that the team was informed of the schedule. The interviewee said *"since I have done this* [CII research] *a few times, I always feel like I have to constantly remind them of what stages we are going to go through before we report out."*

When he was asked about having two co-chairs on a CII research team, the interviewee perceived *"good to have a co-chair"* in having a back-up and maintaining both views on a team.

> *"I guess the reality is that it seems like people are busier now than they were in the past. The demands on their times are greater. So, maybe the times where the chair just cannot be there, especially with global travel, that's where good to have a co-chair. …… Usually what they do, I think it's good to have both side representatives. …… I think that makes sense. In that way you keep both side kind of pieces. I think it's good to have both views."*

2.4.3 Team relationship

According to the interviewee, the team had a mutual respect as discussed in the previous section. When asked if there was any conflict within the team, whether it was over the research or personalities, he recollected one conflict that was associated with the deliverables of this team. He mentioned that a couple of members *"wanted to address some issues"* that the rest of the team thought were beyond the mission statement.

> *"Actually only conflict I can think of was when we were doing finalizing this report. What we were going to put in here* [research summary]*, and there were two people wanted to address some issue. …… They thought they had found some good stuff and we should put that in as well. And the rest of the group basically said "Well, look at the mission statement. We don't get into that"".*

The team meeting was held *"every two months"*, and the meeting minutes were taken mostly by the chair's secretary. The interviewee said that when the chair *"didn't have the secretary, he would just get the volunteer and try to get a different volunteer each time"* to take meeting minutes.

2.5 PRODUCT DESIGN AND DEVELOPMENT

Key comments from the in regard to research products are presented in Table M3-6. The interviewee assessed the quality of the deliverables that the team produced as *"incredibly high"* in terms of implementability. The interviewee further elaborated that *"it's already implemented on some projects"* and *"companies are already doing it"*.

"..... Construction jobs are laboratory. Go to the construction jobs, find out who's doing what, the companies that are doing more innovative things that are really successful, those are the ones we report. So, in terms of implementing, I mean, it's already implemented on some projects, so, implementability is incredibly high because companies are already doing it. So, that's strong."

Question Category	Interviewee (Academic – PI)
Product Quality	• Implementability is incredibly high because companies are already doing it.
Industry Member Involvement	• Basically, I wrote the research summary.
Feedback	• I would almost have to say phenomenal. • By far very well received and it continues being well received.

Table M3-6: Product Design and Development

In regard to the involvement of the industry members in developing the RS, the interviewee said that he wrote the research summary. The industry members were

involved in developing the research summary, but it was reviewing the research summary in a meeting.

> *"……Basically, I wrote the research summary. Every project that I have been on as the PI, I usually write the research summary. We start out with being stated when we meet in Austin that it's the team is supposed to do the research summary. I remember a meeting in Houston one to go over the research summary, it was just, they would get bogged down things, and, it was, I guess we met at the second time in Houston, and we had different people read, well you read pages one to three, you read three to five, since they wouldn't do the homework, we had them sort of sit in the meeting, "Okay, let's take an hour and a half. Lead those three pages, and let's see what should do". So, they were definitely involved in the research summary, but it wasn't on an independent basis."*

When asked if he had received any feedback from either industry or academia on the research products, the interviewee described it as *"phenomenal"* and *"well received"*.

> *"I would almost have to say phenomenal. This was probably one of the best studies I ever was involved.* [One of his CII research studies], *from a methodology point of view, perhaps a stronger study, but in terms of developing an interest in the industry, by far very well received and it continues being well received."*

The hardcopy sales and e-copy downloads of all products of this team ranked top ten most downloaded CII research teams from 1989 to 2010. This ranking is based on the product sales and downloads that are normalized by the publication year of individual products. The RS of this team is still widely downloaded by CII member companies, being ranked among top 60 most downloaded individual CII products in the year of 2010 as well as in the year of 2011 among more than 400 CII products that were downloaded at least once each year.

Appendix M4

Individual Case Description Report

Distinguished Case: D1

Table of Contents

List of Tables

1. Introduction

1.1 CASE INFORMATION

Table M4-1 summarizes the overall information of the case D1.

Case Category	Distinguished		
Project	Project period	2 years	
	kickoff date	Late October	
Industry Chairs	Number of chairs	2 co-chairs	
	Change in chairs	Owner co-chair	
	Previous CII experience	Yes (both co-chairs)	
Principal Investigators (PIs)	Number of PIs	2 PIs	
	Change in PIs	No	
	Previous CII experience	No	
Team members	Number of members (excl. academics)	Kickoff: 18	Owner: 9, Contractor: 9
		Report out: 14	Owner: 7, Contractor: 7
	Number of industry members with previous CII research team experience (excl. chairs)	1	
Research Methodology	Research Method	Survey	
		Structured interviews	
	Validation Process		
Products	Products published	Research Summary: 1	Published on schedule
		Implementation Resource: 1	Published on schedule
		Research Report: 1	

Table M4-1: Case Information

1.2 DATA SOURCES

The main data source for this case study was individual interviews with 1 academic and 2 industry members. Other data sources to support and/or supplement the interviews included CII Post Research Team Survey (Post RT Survey) responses of this team and CII documents and archival records. The detailed data sources and their availability for analysis are summarized in Table M4-2. All the available sources in Table M4-2 were analyzed to investigate the case from multiple perspectives. Words, phrases, and sentences in italic font with quotation marks in this case description indicate direct quotes from the interviews or comments of the Post RT Survey respondents.

Data Type	Data Source		Available and used for analysis
Interview	3 interviews	1 academics	Yes
		2 industry team members	Yes
Documentation	Team documents (retrieved from CII SharePoint)	Research Topic Statement	Yes
		Proposal	Yes
		Charter	Yes
		Meeting agenda	No
		Meeting minutes	Yes (9 meeting minutes)
		Interim Reports	Yes (2 reports)
		Team roster	Yes
	Research products	Research Summary	Yes
		Implementation Resource	Yes
		Research Report	Yes
Archival Records	CII surveys	CII Post Research Team Survey	Yes
		Annual Conference Evaluation Survey	Yes
	CII records	CII product usage - Hardcopy sales and e-copy downloads numbers	Yes

Table M4-2: Data Sources

1.2.1 Interviews

Three members of this team, the lead Principal Investigator (lead-PI) and two industry members were interviewed. One of the two industry team member interviewees was the owner co-chair. The lead-PI interviewee had no CII research experience prior to this team while both industry interviewees did. Each interview was conducted on a one-to-one basis at a different time and place. Interview durations were about 2 hours for all interviewees. Dialogues of all three interviews were digitally voice-recorded upon the written consent of the interviewees.

1.2.2 CII Post Research Team Survey (Post RT Survey)

A total of 13 industry team members of this team responded to the Post RT Survey. The Post RT Survey is sent by CII to every CII research team member after the team reported out at a CII Annual Conference. The survey analysis considered the ratings and comments that the respondents provided in a narrative form. Since 13 from 14 final members responded to the survey, the ratings based on a five-point scale can be considered the perceptions of the entire team.

1.2.3 Other data sources

Other data sources collected and reviewed for this case were team documents and CII archival records relevant to this case. The team documents included the research topic statement provided to this team by CII, the proposal submitted by the PIs to CII, the team charter, meeting minutes, team rosters, interim reports submitted to CII by the team, and the research products that the team delivered (i.e., research summary, implementation resource and research report). The CII archival records included CII Post RT Survey responses, CII Annual Conference Evaluation Survey ratings, and hardcopy sales and e-copy downloads numbers of the research products of this team.

2. Case Analysis

2.1 CASE INFORMATION

The team started with a kickoff meeting in late October with a target report out date in 21 months. The research topic statement was provided to the team with an essential question and expected potential deliverables.

The original owner co-chair retired and, consequently, resigned from the team approximately six months after the team kickoff meeting. Therefore, one owner member of the team who worked with the chair on a prior CII research team stepped in the chair's

position. The contractor co-chair served on one previous CII research team, and the new co-chair served two CII research teams prior to this team. The original co-chair who resigned did not have prior CII research experience.

The two academics did not have any previous experience with CII research, and this was their first CII research project. The lead-PI is from an engineering discipline other than construction, and the co-PI specializes in construction management. They were at the same university at the beginning of this research project, and both moved to different institutions during the research process.

When the team had a kickoff meeting, the total number of team members was 18 excluding the academic group (two PIs and two graduate research assistants). The numbers of team members from owner companies and from contractor companies were same. 11 members were working in the topic area as manager or director, and the remaining 8 were working as construction manager, engineering manager or engineer when the research started. The final team members, which were listed in the research summary, were 14 industry members and two academics and two graduate research assistants.

A total of 9 meeting minutes were available for analysis. The total number of meetings including face-to-face meetings and conference call meetings was 13, and the minutes of 2 face-to-face meetings were not available. The average number of face-to-face meeting attendees was 12 with an average attendance of 66%. The team had face-to-face meeting every other month starting from the kickoff meeting in October in the first year. Only one industry member except the co-chairs had previous CII research experience.

2.2 STRENGTHS AND WEAKNESSES

Table M4-3 includes key responses of the interviewees about strengths, weaknesses and/or challenges, and unique aspects.

Several strengths commonly noted by the interviewees included experienced team members, good team chemistry and participation, leadership from the co-chairs and PIs, and the use of SharePoint for communication. The lead-PI interviewee also noted that the two co-chairs and the two PIs had *"conference calls for planning purposes"*, such as *"for planning a meeting or developing an agenda"*, which the interviewee thought a strength.

The weaknesses and/or challenges pointed out by the interviewees included lack of previous CII research experience of the two PIs and the research schedule. Interviewee B, the owner co-chair, thought that if the two co-chairs had not had any prior CII research experience, the team would have experienced a difficulty in meeting the research schedule. However, since the two co-chairs knew the CII research process, they were able to overcome this challenge according to this interviewee.

"In some cases, you have really experienced researchers, and they know the 2-year schedule. They know when things have to be done. That wasn't the case [of this team] *because these researchers* [PIs] *were new to CII..... I think if the inexperienced researchers with CII coupled with the inexperienced chairs and co-chairs, it may have been a problem. But,* [the contractor co-chair] *and I kind of drove the team in milestones making sure we were hitting when we needed to hit it on, and* [the two PIs] *took care of the PI responsibilities in trying to support that and meet that schedule."*

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Industry – owner co-chair)	Interviewee C (Industry member)
Strengths	• Experienced members - Chairs were on the prior successful CII teams • Effective use of CII SharePoint • Leadership communication	• Individual background and experience • Good chemistry, synergies and participation • Everyone contributed.	• Variety of people • It was a benefit that we had [two co-chairs and the lead-PI] to continue to push us back and to focus on what CII asked us to look at.
Weaknesses /Challenges		• PIs were new to CII research, so the co-chairs drove the team in milestones. • [The team] did not have time to follow up the survey.	• Research time
Uniqueness	• PIs started writing early. We tried to write [the research products] on-going to avoid work at the end.		

Table M4-3: Strengths and Weaknesses – Interviews

Another challenge that Interviewee B noted was that the team did not have *"time to the follow-up"* the *"preliminary survey to all the BOA members"* because of the research schedule. The interviewee felt that if the team could have done it again, they would have *"pushed the schedule little differently"*.

"It would've been beneficial to have been able to go back to a similar set of people and clarify some of the information provided and some of the gaps that we didn't realize were there. Um, so, that's why I'm saying, if we were redoing it, I think probably, you know, we would push that schedule little differently from our research perspective to try in."

In terms of unique aspects during the team process, Interviewee A mentioned that using CII SharePoint was "*innovative at that time"* even though that is currently a typical practice for CII research efforts. Another unique aspect commented later by this interviewee was that the two PIs "*started writing early"* and "*tried to write"* concurrently with the research progress *"to avoid lots of work at the end"*.

2.3 RESEARCH METHODOLOGY

Key comments from the interviewees in regard to research methodology are listed in Table M4-4.

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Industry – owner co-chair)	Interviewee C (Industry member)
Scoping Phase – Alignment	• [The team did] get consensus pretty quickly. • Strong alignment	• By the third face-to-face meeting	• Took us about six months.
Scoping - Change	• [The team had] no change in the original scope.	• [The research scope] remained consistent.	
Scoping - Industry Background Study	• Yes, [they did]. It was very effective.	• CII research documents related to the topic.	• Partially. [It was sharing] war stories rather than presentations.
Data Collection & Analysis – Data Collection	• Survey • Structured interviews	• Survey and interviews	
Data Collection & Analysis – Industry Roles		• [The industry members] provided feedback [to the data analysis].	

Table M4-4: Research Methodology – Interviews

2.3.1 Scoping

The team started with a kickoff meeting in late October with the target reporting-out date in 21 months. In the kickoff meeting, the team drafted a team which included the research background, the purpose and objectives, the research limitations, the deliverables, and the code of conduct. The two PIs provided a presentation of the proposal that they had submitted to CII. The team also brainstormed potential survey questions for data collection. The overall project schedule and detailed action items for the next couple of months were discussed and determined as well. One unique aspect was that the 4 leaders of the team, two co-chairs and two PIs, had dinner the night before the kickoff meeting for a planning purpose.

The team was aligned on the research scope and direction "*by the third face-to-face meeting*" which was approximately "*six month*" after the kickoff meeting. Once the scope was defined and aligned, it "*remained consistent throughout the process*". Interviewee A, the lead-PI, described that the alignment of the team was *"strong"* without *"a lot of challenges"*. The major research activities in this six-month period included defining the research objectives, discussing what to achieve and what to deliver, and reviewing relevant CII publications.

Interviewee B, the owner co-chair, mentioned about the importance of clarifying the CII research process at the beginning as part of the alignment process as quoted below.

> *"……the first thing that people want to know is what the* [research research] *process is. And I think if the leadership of the team, whether it's on the academic side or industry side, know what that process is and can clearly communicate how the whole things going to work, that provides a certain amount of clarity so that people can see that because a lot of time that's almost more a concern than topic is – how often we are meeting and how much time we are going to be spending and how much time I am going to be spending outside of the team, that type of thing – if people have not been on the team before. So providing clear information about the direction of a team is going to take is really important to that whole forming process."*

In the scoping phase, reviewing the CII publications related to the topic took the team a lot of time. To speed up this review process they divided the whole team into smaller groups and had each group report back what they did to the entire team. The review and presentation of the relevant CII publications continued until the 8th face-to-face meeting.

A key challenge was the change of the co-chair midway through the project. Interviewee B was recommended as a replacement by the contractor co-chair since they

had worked together on a prior CII research team, said Interviewee B. Interviewee A commented that the two co-chairs "*worked out very smoothly*" because of the previous research and work experience of the contractor co-chair and the new owner co-chair.

2.3.2 Data collection and analysis

The data collection was conducted using two methods, the survey and structured interviews. Originally, two surveys and following in-depth interviews were planned for data collection. In the fourth face-to-face meeting, the PIs gave a presentation of the first survey analysis to the team, and the team discussed the results question by question. The PIs raised a question as to the need for a second survey. After a lot of discussions, the team agreed to directly proceed with in-depth interviews without doing the second survey. Interviewee B recollected this decision on conducting the in-depth interviews.

> *"From a schedule perspective, that's when we just decided we didn't have time to do a second survey and got into the interviews. So what we tried to do then was to put together a very comprehensive interview package that would be used for in-depth interviews. ……I think we decided it as a team……"*

In this fifth meeting, the team formed subgroups to collect data and to develop research deliverables including the research summary and the implementation resource. During every face-to-face meeting afterwards, the team had a breakout session for subgroup meetings, and the subgroup leaders reported back the work progress to the entire team after a breakout session.

In the sixth face-to-face meeting, the team reviewed the interview questions drafted by the PIs and provided input. In the following face-to-face meeting in about three months, the PIs presented the interim findings of the interviews. In the eighth meeting, the PIs made a presentation of the interview findings and asked the team to provide their interpretation and feedback.

Table M4-5 shows the Post RT Survey responses of this team for the questions related to data collection. From a total 12 respondents, no respondents answered 'Disagree' or 'Strongly Disagree'. In general, the team seemed to be satisfied with their data collection and analysis process except the amount of data collected. Some respondents made a point that more data would have been *"desirable"*.

Survey Question	Responses	Comment
The team had an appropriate and well organized data collection plan.	• A total of 12 responses • 'Strongly Agree' – 3 • 'Agree' – 9	• Yes, very much so. The team spent several sessions fine tuning the scope and process for surveys and interviews
The data collection plan was well executed.	• A total of 12 responses • 'Strongly Agree' – 5 • 'Agree' – 7	• Yes, the process was just as important to us as the scope (e.g., content) of the surveys and interviews.
There was strong CII member support in the data collection effort.	• A total of 12 responses • 'Strongly Agree' – 2 • 'Agree' – 7 • 'Neutral' – 3	• Commitment and professionalism by the group • Everyone participated to do their part. • Survey responses could have been better. • More participation was desirable.
The quality of data collected and overall research met my expectations.	• A total of 12 responses • 'Strongly Agree' – 5 • 'Agree' – 7	• There are some areas within our topic that I felt could have been pursued more thoroughly and included within the research. • It would have also been nice to make a stronger attempt to obtain data from non-CII companies to explore their best practices and areas of emphasis. • Everyone had the opportunity to comment.

Table M4-5: Post RT Survey Responses - Data Collection

2.4 TEAM DYNAMICS

2.4.1 Team participation and commitment

Key comments from the interviewees in regard to team participation are listed in Table M4-6.

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Industry – owner co-chair)	Interviewee C (Industry member)
Team Composition		• Knowledge and experience, decision making power really helped.	
Team Diversity	• It could have been more diverse.		• Typical
Team Attrition	• One retired, two dropped out, one less active.	• Maybe a couple of people.	
Meeting Attendance		• Feel like 80%	
Core Group		• At least ten members were very involved last six to nine months.	• Six or eight besides two academics
Subgroups	• Preparing research documents • Annual Conference presentations • Literature review	• Writing deliverables and preparing the Annual Conference presentations. • Very clear strategy from the beginning to break into sub-teams.	
Participation & Commitment	• Strong participation • Very high functioning team.		
Factors for Participation & Commitment	• Highly motivated team. • Strong leadership and well-functioning team.	• We had really experienced people who were very passionate about the topic.	

Table M4-6: Team Participation and Commitment – Interviews

2.4.1.1 Team composition and diversity

Interviewee A described that the team had a *"good balance of owners and contractors"* even though *"it could have been more diverse"*. However, this interviewee added that the team *"had people with a lot of experience and experience with CII"*, which the interviewee thought helped the team a lot. In terms of CII research experience of the team members, only one industry member and the two co-chairs had prior CII research experience.

Interviewee B also noted the team composition. This interviewee specifically pointed out that the team had the members with *"power"*, which meant the company positions that the members held, so that the team was able to make decisions during the team meetings according to the interviewee.

> *"……you make a lot of decisions in team meetings. And if you have a team made up of people who have to go back* [to their companies] *and talk to* [them]*……then you can't make those decisions effectively in team meetings. ……we had really the decision makers, the people who were knowledgeable about it for the most part in the room. And, that I think really helped facilitate the whole process……They were the people how the* [topic related] *systems were structured and how they were used and accessed and what information and data could be pulled from them. ……So, I do think, that contributed to the success of the team and the quality of the results."*

Interviewee C provided his perspective on team diversity in general. This interviewee thought that diversity was necessary to have different opinions, and, at the same time, the leaders needed to *"get the best consensus"*.

> *"The challenge there is that the leader needs to channel that* [diverse opinions] *at the right time because you have a schedule. So, much diversity you have and you still want to keep channel and get the best consensus you can, and otherwise you won't get it done because you have too many different opinions. ……So, that' the role of the leaders to facilitate that process and get that going so you start heading down to a direction."*

2.4.1.2 Team attrition and meeting attendance

The interviewees' recollection about team attrition and meeting attendance was positive. The team lost four members at the time of report out at the Annual Conference compared with the initial members at the kickoff meeting. The average meeting attendance based on the 9 meeting minutes was 66%, about 12 members attending each

face-to-face meeting excluding the academics. The industry members attended more than three face-to-face meetings were 15, and 12 attended more than 5 face-to-face meetings of the 9 face-to-face meetings.

2.4.1.3 Core group

According to Interviewees B and C, the team had a core group of at least ten members including the PIs. The core group of members here refers that the team members who actively participated and were involved in developing and writing the research summary or implementation resource and preparing presentations for the conference according to Interviewee B. This recollection of the interviewees on the core group is consistent with twelve industry members who attended more than five meetings out of nine face-to-face meetings.

2.4.1.4 Factors for team participation and commitment

The team had "*strong participation*" from team members. Only the team lost a couple of industry members (one retired and one dropped out), and 2 PIs and 14 industry members still remained on the team roster two months before the CII Annual Conference where they reported out. To the question about the factors for the high level of participation, Interviewee B responded that the team had "r*eally experienced people who were very passionate about the topic*." Interviewee A responded very similar. Interviewee A noted that member's desire to make contributions and to learn from the research highly motivated them for active participation. In addition to this, Interviewee A suggested another perspective about team participation.

> *"We had strong leadership and we were well functioning team, so it is easy to remain in a team which is working well. People don't want to work on the team which is not functioning well, where are a lot arguments and dysfunctional, because it is not good experience to be on that kind team. But we were accomplishing things and we were successful, so people wanted to continue to participate."*

Interviewee B mentioned about the relationship between the level of member engagement and the degree of interest and passion about a research topic.

> *"…and so, I think sometimes you have a team made up of the people who were volunteered by other people and other times you have a team made up of people who are passionate about a certain topic. And because of that, they aren't just engaged start to finish."*

2.4.2 Leadership

Key comments from the interviewees and Post RT Survey respondents in regard to team leadership listed in Table M4-7 and Table M4-8, respectively.

The leadership of this team was "*mixed*" and a "*good balance*" between the academics and industry leaders. Interviewee B recollected that *"there was a good balance between the industry leadership and the PI leadership"*, and the interviewee did not recall *"there was any domination one side, or the other"*.

There was "*strong leadership*" from the industry leaders. Interviewee A described the chair and the co-chair as "*good managers*", "*task managers*", and "*confident leaders*". The industry leaders also had "*good communication skills*", for example, setting "*agendas in advance and sending reminders to everybody*". The co-chairs were also "*available and quickly responded* [to the PIs]", which Interview A thought important. The co-chairs were "*very organized and focused*", "*making sure people took* actions" and "*keeping the team on track*". Interviewee C commented that the co-chairs and the PIs did a good job in keeping the team focused.

> *"We had a variety of people with different goals in mind, in my opinion, and interests as well……It was a benefit that we had* [the co-chairs, and the lead PI] *to continue to push us back and to focus on what CII asked us to look at."*

Interviewee B, the owner co-chair, described the contractor co-chair as *"a very respectable leader for the team"* with *"CII experience and* [topic related] *background"*. Thus, the interviewee thought there was *"a good leadership"* from the beginning, and further commented as presented below.

> "……[the contractor co-chair] *was very good about documenting action items and following up and making sure people took those actions. And I think those are important qualities because when you document action items……I think* [the contractor co-chair] *really provided tremendous leadership to the team. I think I learned a lot from* [the contractor co-chair] *about leading teams during that experience……"*

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Industry – owner co-chair)	Interviewee C (Industry member)
Leadership	• Industry leaders were good leaders and good managers and familiar with the CII research process.	• A good balance between the academics and the co-chairs	• Mixed [PIs and chairs]
Chairs	• Had previous research team experience and work experience • Hold strong leadership. • Were very confident leaders. • Had good communication skills.	• [The contractor co-chair] had good leadership and organizational skills and kept the team on track	• The co-chairs did a lot of work.
Expectations established by chairs	• [Expectations were stated in the] team charter.	• [The co-chairs] were very clear as our goal from the beginning.	
Two Chairs	• I think that's good not to lose both perspectives.		
PIs		• Passionate and enthusiastic. • They focused on what each of them could bring to the table.	• [The lead-PI] was very organized, very detail, very careful, and very precise.
PI & co-PI	• Had previously worked together on some research.	• Two complemented each other.	• [The two PIs] worked very well together.
Leadership Communication	• Yes. Conference calls for planning purposes.	• Yes. [But] not formal meetings.	
Leadership Roles & Responsibility	• The chairs establish their roles and responsibilities at the beginning.	• PIs: administrative activities (meeting notes), and research related activities. • Chairs: planning and orchestrating of the meetings and adherence the milestone schedule.	

Table M4-7: Leadership – Interviews

Survey Question	Responses	Comments
The Principal Investigator(s) (team academic(s)) did a good job of structuring and facilitating this research.	• A total of 13 responses • 'Strongly Agree' – 8 • 'Agree' – 5	• Very well done. our academics (and team co-chairs) held us together and did an awful lot of work
The Co-Chairs provided the expected leadership necessary for team success.	• A total of 13 responses • 'Strongly Agree' – 8 • 'Agree' – 5	• Initial Co-Chair resigned after 1 year. This was a significant disruption. • [The contractor co-chair] did an outstanding job of keeping the team focused and on track. • Our chair in particular performed superbly. Co-chairs changed in mid-stream due to a retirement.
The academic support (development of methodology, facilitation, data analyses, meeting support, etc.) was appropriate and met my expectations.	• A total of 12 responses • 'Strongly Agree' – 6 • 'Agree' – 6	• [The PIs] did an excellent job of analyzing the data and willingly accepted suggestions on analysis approach from the team. • Excellent. They and the co-chairs did more than their share of coordinating, facilitating and contributing.

Table M4-8: Team Leadership – Post RT survey Responses

The two PIs also worked well together, said both industry interviewees. The two PIs were from different academic disciplines. However, Interviewee A said that they knew each other well since they had previously worked together. When they started, they worked at the same university, but they moved to different universities in the midway through the research project. The two PIs and two graduate research students had a conference call every week for communication after they moved to different universities.

Interviewee B, the owner co-chair, said that two PIs complemented each other. Even though they were from different disciplines, the interviewee pointed out that they understood and knew what the strengths of each other were and focused on strengths that each could bring to the team. In addition, the two PIs "*were willing to learn from the*

industry members" and "*relied on industry input and contributions to shape the research direction*", which the interviewee thought helped the team engage in research activities.

> *"…..they* [the PIs] *were very enthusiastic. So, it was evident from start that although they lacked kind of knowledge and understanding of the CII research process, that they were very passionate about the topic, they were enthusiastic about having the opportunity. ….… they were, even as the PIs, willing to learn from us as industry members. You know, they weren't coming to the team and saying we are experts in this.…… they were willing to learn from us ….… so, I do think that helped engage the team, seeing that they weren't going to just sit there and tell us how do everything because they were the experts. But they were really relying on our input and out knowledge and our contributions to help shape the direction of the team. So, I think that was beneficial."*

Interviewee B also noted that previous work experience between the PIs was *"beneficial"*. Because of this previous working relationship, the interviewee thought *"they* [the PIs] *worked well together"* even after the PIs moved to different institutions during the research process.

The respondents of the Post RT Survey provided positive answers to the leadership related questions. All of them responded 'Strongly Agree' or 'Agree' showing no negative responses (i.e. 'Disagree' or 'Strongly Disagree'). The comments provided the survey respondents were also all positive in regard to what PIs and co-chairs worked for the team.

2.4.2.1 Leader expectations

Interviewee A said that the expectations established by the co-chairs were stated in the team charter. The charter includes the background, the research purpose and objectives, and the deliverables. The charter states that the research summary would be developed by the industry members in the deliverable section. According to Interviewee B, the co-chairs clearly stated from the beginning that they wanted to their deliverables to be approved by the CII Product Review Board (PRB) before the CII Annual Conference. By achieving this, their products would be available to the CII member companies when they would make presentations at the conference. They also established and communicated a strategy, *'divide and conquer with sub-teams'*, to achieve this expectation.

2.4.2.2 Leadership roles and responsibilities

Interviewee A, the lead-PI, recalled that the PIs *"did not really understand"* their roles and responsibilities *"at the very beginning"* of the research. However, the

interviewee added that it was *"a learning curve"* to figure out what to do. The interviewee recommended to other academics without CII research experience *"understand that this* [CII research] *is very different from what they* [academics] *used to do."*

According to Interviewee B, the co-chairs took *"responsibility for planning and orchestrating of the meetings and adherence the milestone schedule"* while the PIs took *"a responsibility for administrative activities associated with the meeting"*, such as *"taking meeting notes"*, following up *"parking lot items and action items"*, as well as research related activities.

2.4.2.3 Leadership communications

Interviewee A recalled that the two PIs and two co-chairs *"had dinner the night before the team kickoff meeting for the planning purpose"*, and had conference calls as well. In addition, since the PIs moved to different institutions, the academic group, two PIs and two graduate research assistants, *"had weekly conference calls to keep in touch"*.

Interviewee B, who joined the team after the second face-to-face meeting and replaced the original owner co-chair, mentioned that it would have been much more beneficial if the co-chair and she had *"independent meetings"* outside the team meetings. By doing separate leadership meetings, she thoughts that she could have quickly understand *"what the team was up to"* from the leader perspective and better been prepared as a leader.

2.4.3 Team relationship and communications

Key comments from the interviewees and Post RT Survey respondents in regard to team communications listed in Table M4-9 and Table M4-10, respectively.

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Industry – owner co-chair)	Interviewee C (Industry member)
Conflicts			• No. No opinionated people.
Team Meetings	• Identified action items, and who was responsible for action items and due dates. • At the beginning of every meeting, we pulled out and looked at the statement of work (charter).	• Started every meeting with review the charter and deliverables • Well organized and orchestrated, [which] helped with the leadership and achievement of the goals for the team	• Pretty open and less fear of talking about what worked and what didn't.
Social Activities	• Team dinners, went to hockey games, etc.	• team dinners	

Table M4-9: Team Communications – Interviews

Survey Question	Responses	Comments
The research team was properly aligned throughout the project.	• A total of 13 responses • 'Strongly Agree' – 4 • 'Agree' – 7 • 'Neutral' – 1 • 'Disagree' – 1	• Not at the beginning of the research. Having new members that have never been on an RT with different background is the reason for not having all aligned at the beginning of the project. However; with the leadership of the Team Leader, all came together. • The research team did not develop a good vision of the output of the research to facilitate generation of the research products with minimum time and effort. • Very well aligned.
The research team got off to a good start.	• A total of 12 responses • 'Strongly Agree' – 5 • 'Agree' – 5 • 'Neutral' – 2	• Due to the scheduling of the first few meetings I was not able to participate during the first three months the team was together. By the time I became involved I felt the team was a little behind schedule in performing the research necessary to meet the team objectives. I do believe things came together and got back on track. • Yes, we had a charter drafted the first day.
The research project plan and schedule were communicated and agreed to before significant work began.	• A total of 12 responses • 'Strongly Agree' – 4 • 'Agree' – 7 • 'Neutral' – 1	• Yes, via the CII scope of work (original academic submittal with CII's additional requirements) and then in the charter.

Table M4-10: Team Communications – Post RT Survey Responses

Survey Question	Responses	Comments
What was the research team meeting frequency (both face-to-face and by phone/web?)		• At the beginning face-to-face every second month with 1-2 phone call sin between. Then bi-weekly conferences towards the final 6 months. • Quarterly, then monthly then bi -weekly till just before the report out at the annual conference. • Face to face meetings were conducted every 3 months initially and became more frequent during the last 6-8 months prior to the Annual Conference. Teleconference calls were typically held in between the face to face meetings. • In-person every other month. ……As the team moved into the last 6 months, sub-teams met more frequently and full team conference calls were scheduled every two weeks.
The research team meeting frequency (phone, web, face-to-face) was appropriate and efficient.	• A total of 12 responses • 'Strongly Agree' – 7 • 'Agree' – 5	

Table M4-10, continued.

2.4.3.1 Team Meetings

Interviewee B recollected that the co-chairs *"started every meeting review the charter and what deliverables were"*, which the interviewee thought created a *"focus for the team"*. In addition, the team *"reviewed industry responsibilities and action items, and follow-ups"*.

"……So, everything was very well orchestrated, and the agendas for the meetings and everything fit in a spot, flow pretty well.....So, it was very well organized, and I think that helped with the leadership and achievement of the goals for the team."

Every team meeting was *"very well organized"* and *"orchestrated"*. The face-to-face meetings were structured so that every meeting was operated in a same way as listed below.

- Day 1: safety moment, charter review, agenda review, review of previous meeting minutes, review of previous action items, report and review of data collection status and findings
- Day 2: research plan path forward, review project schedule, action items, meeting plans

Interviewees A and B both mentioned about the benefit of starting each meeting with the review of charter.

> *"At the beginning of every meeting, we pulled out and looked at the statement of work to make sure that we were on track and aligned with the charter. That was very helpful."* – Interviewee A

> *"We started every meeting reviewing our charter and what were deliverables, so we kind of created that focus for the team."* – Interviewee B

The team meetings were run by the industry leaders and the PIs. As the research project passed the halfway, the PIs took more part in the team meetings presenting data analysis and findings and leading the team discussions in relation to that. Interviewee B mentioned about the preparedness of the PIs with their part in the meetings.

> *"They had already gone through and completed a huge amount of analysis that was put into very detailed PowerPoint.…when you present this organization, you know, people can't say, oh, we didn't get anything out of the meeting…"*

Interviewee B also commented how the team operated the meetings in detail.

"I would say I think the way we did it was at each meeting we set the agenda for the next meetings, so the PIs knew what they were going to have to report on, and the industry members knew if they had homework or assignments that they were going to have to contribute, so at the end of each meeting, we went through the agenda for the following meeting. …… the meeting minutes and everything were documented by graduate students..... I would say that generally [the contractor co-chair] *would launch the meeting…… very organized meetings, and then if it was a report from the PIs and how they were coming with the survey or review of the survey or re review of the data, then that's exactly what they would say……so, I would say they* [the meetings] *were more coordinated by industry, but kind of a joint leadership depending on the topic of the discussion."*

2.4.3.2 Social activities

The team dinner for a face-to-face meeting was the main social activity of this team. Besides team dinners, the team went to hockey games together, and some members even ran together the morning of a face-to-face meeting according to the interviewees. These small and fun activities helped the team members maintain the relationship, according to Interviewee A.

In addition, Interviewee B mentioned about topic-related alignment and emphasized the importance of creating a non-threatening environment for speaking out individual opinions through building personal relationships by having social activities.

"As far as the topic, I think this team formed fairly well not that there weren't any diverging opinions, but that I think everybody in the room was respected for their background and experience and what they are going to bring to the table and that coupled with strong participation …… the environment you have to create, you have to create an environment where's not going to be criticism, there's not going to be judgment but there's going to be acceptance of everyone's contributions. …… it's also, in my opinion, really important to those beginning meetings that the team's having that everybody take the opportunity to go out to dinner together or eat lunch together so that they talk not just about the research of the team but get to know each other as individuals and professionals."

2.5 PRODUCT DEVELOPMENT

Key comments from the interviewees and Post RT Survey respondents in regard to the research products listed in Table M4-11 and Table M4-12, respectively.

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Industry – owner co-chair)	Interviewee C (Industry member)
Product Quality	• Very pleased and very proud of that. • Finished on time, and produced quality products.	• Implementability: 7.5 or 8 on a one to ten scale.	• It tells you how generally the companies are and all the standards.
Key Considerations in Tool Development	• It evolved as we collected our data.	• Value to the member companies.	
Feedback on the Products	• AC presentation was well attended and received good feedback.	• Positive feedback at the conference. • The co-chairs presented at the CII Performance Improvement Workshop (PIW).	

Table M4-11: Research Products – Interviews

Survey Question	Responses	Comments
The research project deliverables (Research Summary and Implementation Resource, if appropriate) were most suited to improve performance of CII member companies.	• A total of 13 responses • 'Strongly Agree' – 9 • 'Agree' – 4	
The topic and research conducted were consistent with what I initially expected.	• A total of 13 responses • 'Strongly Agree' – 5 • 'Agree' – 6 • 'Neutral' – 2	• Mostly it was valuable. It did not cover address what is next for [topic] nor did it contain sufficient information on Metrics. • ……The research results were valid and very useful to CII members…… • Very well thought out and executed. • Initially my expectation was for a more rigorous investigation and analysis. However, I now feel the scope was in line with the time allotted.

Table M4-12: Research Products – Post RT Survey Responses

A subgroup approach was utilized to develop and write up their research products. The required deliverables by CII are a research summary, and a research report. An implementation resource is optional and whether to deliver it or not is a research team's decision. This team decided to deliver an implementation resource. Therefore, the team was divided into three groups specifically for product development. The contractor co-chair took charge of the research summary subgroup, and the owner co-chair led the implementation resource subgroup. The two PIs and two graduate students were responsible solely on developing the research report since the research report is a comprehensive academic research report.

The interviewees were satisfied with their research products. Interviewee B said that the implementability would be 7.5 or 8 on a 1 to 10 scale. This interviewee added that their products have *"been well accepted by industry, people who have seen the product are happy with contents of it and the direction"* that the products provide. The responses of the Post RT Survey also indicated that the survey respondents were satisfied with the products.

The team received positive feedback at the conference where they made presentations about their research outcomes. According to Interviewee B, the co-chairs presented their research outcomes at the CII Performance Improvement Workshop (PIW). This interviewee thought that this experience *"really helped with the perceived success of the industry"* since presenting the research outcomes at the conferences and making the products available *"on the website"* does not provide a greater opportunity for success *"unless the topic really fires on the people"*. In that sense, this interviewee considered PIWs as *"more effective for broader acceptance of practices"*. For research, if it is not *"being reviewed and presented at the PIWs"*, the interviewee thought the research *"has a disadvantage for industry acceptance regardless how good it was"*.

Appendix M5

Individual Case Description Report

Distinguished Case: D2

Table of Contents

List of Tables

1. Introduction

1.1 CASE INFORMATION

Table M5-1 summarizes the overall information of the case D2.

Case Category	Distinguished		
Project	Project period	Total 3 years	one year extension
	kickoff date	Mid-October	
Industry Chairs	Number of chairs	2 co-chairs	
	Change in chairs	Yes	
	Previous CII experience	No	
Principal Investigators (PIs)	Number of PIs	2 PIs	
	Change in PIs	Yes	The co-PI dropped out
	Previous CII experience	Yes	Both PIs
Team members	Number of members (excl. academics)	Kickoff: 32	Owner: 17, Contractor: 15
		Reporting out: 24	Owner: 12, Contractor: 12
	Number of members with previous CII research team experience (excl. chairs)	2	
Research Methodology	Research Method	Case Studies	Qualitative
	Validation Process	Two processes	
Products	Products published	Research summary: 1	
		Implementation resource: 1	
		Research report: 1	

Table M5-1: Case Information

1.2 DATA SOURCES

The main data source for this case study was individual interviews with 4 members of this team. Other data sources to support and/or supplement the interviews included CII Post Research Team Survey (Post RT Survey) responses of this team and CII documents and archival records. The detailed data sources and their availability for analysis are summarized in Table M5-2. All the available sources in Table M5-2 were analyzed to investigate the case from multiple perspectives. Words, phrases, and

sentences in italic font with quotation marks in this case description indicate direct quotes from the interviews or comments of the Post RT Survey respondents.

Data Type	Data Source		Available and used for analysis
Interview	3 interviews	1 academic	Yes
		2 industry team members	Yes
Documentation	Team documents (retrieved from CII SharePoint)	Research Topic Statement	Yes
		Proposal	Yes
		Charter	Yes
		Meeting agenda	Yes
		Meeting minutes	Yes (11 face-to-face meeting minutes)
		Interim Reports	Yes (four reports)
		Team roster	Yes
	Research products	Research Summary	Yes
		Implementation Resource	Yes
		Research Report	Yes
Archival Records	CII surveys	CII Post Research Team Survey	Yes
		Annual Conference Evaluation Survey	Yes
	CII records	CII product usage - Hardcopy sales and e-copy downloads numbers	Yes

Table M5-2: Data Sources

1.2.1 Interviews

For this team, 4 members of this team were interviewed. One was an academic researcher, the lead-PI, and 3 were industry team members. One industry member interviewee was one of the two co-chairs. Each interview was conducted on a one-to-one basis at a different time and place. Interview durations ranged from 1 to 2 hours with an average of 1 hour and 40 minutes. Dialogues of the interviews were digitally voice-recorded upon the written consent of the interviewees.

1.2.2 CII Post Research Team Survey (Post RT Survey)

A total of 8 team members of this team responded to the CII Post RT Survey. The Post RT Survey is sent by CII to every CII research team member after the team reported out at a CII Annual Conference. The analysis for this case considered their rating distributions and 'comments' that the respondents provided in a narrative form. However, since the survey respondents were less than half of the entire team, any statistics on the respondents' ratings based on a five-point scale were only regarded as referential.

1.2.3 Other Data Sources

Other data sources collected and reviewed for this case were team documents and CII archival records relevant to this case. The team documents included the research topic statement provided to this team by CII, the proposal submitted by the PIs to CII, the team charter, meeting minutes, team rosters, interim reports submitted to CII, and the research products that the team delivered (i.e., research summary, implementation resource and research report). The CII archival records included CII Post RT Survey responses, CII Annual Conference Evaluation Survey ratings, and hardcopy sales and e-copy downloads numbers of the research products of this team.

2. Case Analysis

2.1 CASE OVERVIEW

This team started as a two-year research team, and it was extended another year. The research topic statement, which was provided by CII, specified its expected or potential deliverable as a best practice report and stated not to include a tool as a deliverable. The team started with a kickoff meeting in mid-October with a target report out date in 21 months. In the kickoff meeting, the team drafted a team charter that included research background, purpose and objectives, scope, specific deliverables and team expectation and norms.

The two original co-chairs were replaced by other team members. The original owner co-chair was assigned to a project overseas, and the contractor co-chair stepped down as the company withdrew from CII membership. The team replaced them with two other team members in the last year of the project. The two PIs had previous CII research experience serving as PIs on two CII research teams. Both PIs had a civil engineering background specializing in construction management.

The initial members of this team were 32 industry members, 2 PIs and 1 graduate student. The kickoff meeting roster listed 17 owner members and 15 contractor members.

Most of the team members were in manager positions except several members who were in a senior executive level. The final team members were 24 excluding the academics as listed in the research summary. The members from owner companies and contractor companies were evenly distributed among 24 final members.

From the analysis of the meeting minutes of this team, the average number of attendees of 11 face-to-face meetings was 14 with an average meeting attendance of 50%. The team had a face-to-face meeting every 8 to 10 weeks starting from the kickoff meeting in October in the first year. Two industry team members excluding the co-chairs had previous CII research experience. Both of the original co-chairs had not participated on CII research team before this team, and one of the new co-chairs had previous CII research experience.

2.2 STRENGTHS AND WEAKNESSES

Table M5-3 includes key responses of the 4 interviewees to the question asking some strengths and weaknesses of this team. The key strengths of this team perceived by 3 interviewees were first, team expertise and knowledge and second, active participation of the team members. Some weaknesses and/or challenges mentioned by the interviewees were alignment and loss of team members.

One of the weaknesses that Interviewee A, the lead PI, strongly felt about was having a couple of opinionated people on the team. Because of those people, the interviewee thought that the team *"had hard time reaching alignment"* and *"team atmosphere"* became *"pretty negative"*. Moreover, this interviewee said *"the co-chairs didn't know what to do"* about that situation. The interviewee added that *"the rest of the team did fine"* after those two opinionated members dropped out the team. However, this was not mentioned as a weakness of the team by the industry interviewees. Only one of the industry interviewee commented that there was a member with strong personality later in the interview when he was asked about if there was any personality conflicts in the team.

Another challenge only mentioned by Interviewee A was management of a large team. The interviewee said *"One of the negatives having a too big team is keeping everybody busy."* This team started with 32 industry members. The number of industry members on a typical CII research team is 20, 10 from owner side and contractor side each. A total of 27 CII research teams that started last five years except this team had an average of 17.5 industry members in initial staffing. The largest team had initial 23 industry members and the smallest started with 9 industry members. Compared with those 27 teams and compared with even the largest team, this team certainly had more team members than typical CII research teams did, which might have been a challenge for the lead-PI to keep everybody involved and engaged.

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Industry – contractor co-chair)	Interviewee C (Industry member)	Interviewee D (Industry member)
Strengths	• The team members were very knowledgeable. • Those that stayed on were very helpful and did a lot of work.	• Several experts. • Continuity and consistency of the team members.		• Type of people • Diverse participation
Weaknesses / Challenges	• Alignment issue - two very opinionated people. • The co-chairs didn't know what to do. • Lost many people after one year extension. • Having a too big team.	• The co-PI did not align with the team. • The economic situation was a little bit problematic • The team members were doing a lot more - challenge	• One year extension - lost some people. • Economic downturn - lost participation. • Some people with no basic understanding • Misalignment between two academics	

Table M5-3: Strengths and Weaknesses – Interviews

2.3 RESEARCH METHODOLOGY

Key comments from the Post RT Survey respondents and the interviewees in regard to research methodology are listed Table M5-4 and Table M5-5, respectively.

Survey Question	Responses	Comments
The team had an appropriate and well organized data collection plan	• A total of 9 responses • 'Strongly Agree' – 2 • 'Agree' – 4 • 'Neutral' – 2	• We had a smaller group that worked on the case study and questionnaires.
The quality of data collected and overall research met my expectations.	• A total of 9 responses • 'Strongly Agree' – 1 • 'Agree' – 5 • 'Neutral' – 2	• The data we collected was more qualitative than quantitative.
The data collection plan was well executed.	• A total of 8 responses • 'Strongly Agree' – 2 • 'Agree' – 4 • 'Neutral' – 2	

Table M5-4: Research Methodology - Post RT Survey

2.3.1 Scoping

The team spent *"the first two meetings on scoping" – "what the team was going to do"* according to Interviewee A. Interviewee B said that *"by the third meeting"*, the team *"knew what* they *were trying to accomplish"*. However, Interviewee C recollected that *"the biggest challenge"* during the initial phase was *"getting an agreement between contractors and owners around exactly what the topic was what the deliverable was going to be"*. Interviewee D also recalled that *"alignment was tough"* and it *"took long"*. Nonetheless, he thought *"it was worthwhile"* and *"it was good we* [the team] *did invest so much time in the beginning for alignment."* Once the team was aligned, the scope did not change except *"minor adjustment"* to the charter. One of the Post RT Survey respondents also thought that debating the research scope in early phases helped the team focused.

> *"……The team spent several early meetings debating the purpose and scope which were well served later in the engagement. This allowed us to remain focused on our goal."*

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Industry – contractor co-chair)	Interviewee C (Industry member)	Interviewee D (Industry member)
Alignment around the Scope	• The first two meetings spent on scoping. • Alignment took quite a while because of the two opinionated people.	• By the 3rd meeting	• The biggest challenge was getting an agreement between contractors and owners. • Everybody was in alignment.	• It was good we did invest so much time in the beginning for alignment. • After alignment, the process was easier and better.
Scope Change	• No.	• It wasn't a major adjustment, but we made some changes.		
Data Collection	• Preliminary survey • Case studies	• Survey across the team members [companies] • Case studies	• Gathering the team's knowledge. • Case study analysis	
Data Collection - Challenges	• Not enough data.	• Amount of data	• Getting case studies [from companies].	• It was tough to persuade the company.

Table M5-5: Research Methodology – Interviews

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Industry – contractor co-chair)	Interviewee C (Industry member)	Interviewee D (Industry member)
Data Collection - Industry Roles	• Helped develop the case study.	• Enthusiastic to get the surveys together. • Some volunteered to help the case studies.	• Some conducted interviews for case studies.	
Research Period / Extension	• Benefited for data collection.	• That extra year helped us.		• It was a right decision
Industry Member Background Study	• Review relevant CII documents. • Brought their contracts for the team to review.	• Brining of their corporate [cases] • Three or four CII studies		• Provided good feedback.

Table M5-5, continued.

Interviewee A mentioned that *"alignment took a while because of the two opinionated people."* When the interviewee was asked if the research could have been shorter if the team had not had those two negative members, the interviewee said *"it would have been possible"* because *"the remaining team people would have come to an agreement on what to do faster."*

2.3.2 Data collection and analysis

According to the research summary and the research report, the research method was case studies, which was a recommended approach specified in the research topic statement provided by CII. Data collection methods included in-person interviews, the questionnaire to collect quantitative data and information about a case prior to interviews, CII Benchmarking and Metrics data, and expert elicitation. Additional case studies and CII Benchmarking and Metrics data analysis were conducted during the extended year.

Interviewee C described the research methodology as a *"different methodology than what a lot of teams have"*, which he thought worked well for this team. The *"different methodology"* by this interviewee meant that the team started gathering team members' knowledge and developing the implementation resource before starting the data collection effort.

> *"……the product was really about the collective experience of the team and using the case studies for validation, and using the metrics database to help evaluate some of the theories that were around that."*

The research report also confirmed his perception above. The research report stated that the team expertise was *"an important source"* and supplemented other data.

This approach seemed to encourage participation of the industry members. Rather than one linear process, it was a dual process approach where the development of the implementation resource and the data collection efforts progressed concurrently, as Interviewee B said *"that* [data collection] *was before we had really gotten very far along in writings."* As a result, the industry members were motivated to actively participating in the data collection process. The academic interviewee commented about this aspect as presented below.

> *"They [the industry members] wanted to help develop the [interview] questions so that they could get their questions answered and write it in the report. They were pretty motivated because each one of them was committed to help write a section of the final implementation resource, so they were motivated to make sure we were collecting the right data."*

A particular challenge during the data collection process commonly noted by the interviewees was collecting sufficient amount of data. Interviewee C mentioned that a reason for the shortage of projects for case studies was that *"people were reluctant to talk about the projects that were not successful"*. Interviewee D recollected that there was difficulty in persuading the company participating in cases studies and *"people did not want to participate because they were busy."* Interviewee A, the lead PI, also expressed the same difficulty in collecting data as presented below.

> *"Data collection was pretty hard. Part of it is because these companies are all over the world. It is a way more difficult to get data from those companies. ……I was really disappointed that these companies wouldn't give us quantitative data, for example, profits on a job. They will not be willing to give it."*

2.4 TEAM DYNAMICS

2.4.1 Team participation and commitment

Key comments from the interviewees in regard to team participation are listed Table M5-6.

2.4.1.1 Team composition and diversity

Interviewee A perceived that the team composition and diversity as *"more homogenous than typical teams"*, but *"all the team members had specifically* [topic-related] *experience"*, which the interviewee thought *"very good"*.

2.4.1.2 Team attrition and meeting attendance

The initial team members of this team were 32 industry members and 2 academics. The final team industry members were 24, according to the meeting minutes of the last face-to-face meeting and on the research summary. The team lost 8 industry members, which is about 23% of attrition.

Based on the analysis of each meeting minutes of this team, the average attendance of face-to-face meeting is about 14 people, which is about 50% of the team taking into account the team attrition. Among all attendees of total 11 face-face-meetings over the three years of the research period, 14 members attended more than 5 meetings, 11 members attended more than 60% of meetings, and 7 members attended more than 70% of the meetings. In summary, 50% of the entire team attended at least the half of total face-to-face meetings, and one-third of the team attended 70% of total face-to-face meetings.

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Industry – contractor co-chair)	Interviewee C (Industry member)	Interviewee D (Industry member)
Team Composition	• A little more homogenous than typical teams.	• All have the construction background.	• 50% owners and 50% contractors. • Wide range in age. • Relatively good industry representation.	• Knowledgeable and communicative.
Team Attrition	• At least 15 people that were fairly actively through the whole time.		• We lost one-third of the 30 (members).	• Started as a very large group, and many people dropped off right away.
Core Group	• At least 15 people that were fairly actively through the whole time.	• 12 attended 80% of meetings and teleconference.	• 10~12 consistently attending and contributing.	• About ten most active people.
Subgroups	• Wrote products. • Reviewed CII documents. • Helped develop questions for interview.	• We broke it up into different people to different chapters.	• 2~3 person team. • Presented what they had done to the whole group after 6 months.	• Subgroup activities started in the middle of the alignment.
Participation & Commitment	• The industry members developed a conceptual model and interview questions, and drafted a final product.	• Everybody contributed and engaged.	• Very clear that people were very committed.	• Good.
Factors for Participation & Commitment	• Topic - people had a big interest in the topic. • They also enjoyed working together.	• The topic selection was very strong. • The willingness of everyone to contribute. • The need of the industry.	• Very strong group leadership. • The topic was a real problem that people could benefit.	

Table M5-6: Team Participation and Commitment – Interviews

2.4.1.3 Core Group

About 7 to 12 people including the lead PI were very active and considered as a core group according to the interviewees. When the interviewees were asked how many people were in a core group, the interviewees also implied their perceptions on a 'core group' as below.

> *"We had at least 15 people that were fairly active through the whole time. …..… We had 5 to 7 people – core group. They did fantastic. I know some of research teams, that is the size of the whole group at the end. The others also made contributions."* – Interviewee A

> *"There were about 12 strong participants. Probably attended 80% of meetings and teleconferences."* – Interviewee B

> *"There were around 10 or 12 people that you would either always see in person or always be on the phone. They were consistently attending and consistently contributing, whether it be writing or whether it be presentations or supporting that at the conference."* – Interviewee C

It can be derived from these comments that members perceive a core group as team members who consistently and actively attending on team meetings and contributing to research by performing research tasks. As discussed in the previous section, 11 members attended more than 60% of the face-to-face meetings and 7 members attended more than 70% of the face-to-face meetings. The number 7 is close to the number of the core group perceived by the academic interviewee, and 11 is close to what industry perceived as a number core group. The 15 people who were *"fairly active through the whole time"* from the academic interviewee's perspective is close to the number of members who attended more than 50% of the face-to-face meetings, which is 14 members.

2.4.1.4 Subgroup approach

One aspect that recurred across the interviews was that *"everybody contributed and engaged."* This active member participation and contribution was mostly through a subgroup approach that this team adopted very early on the process. The presentation slides of the PIs and the meeting minutes of the kickoff meeting clearly showed that the team took this approach from the very start. The minutes of the kickoff meeting noted that 'Partnering and Team assignment 1' was posted on SharePoint, which means that it was agreed to break the team up into sub-teams at the kickoff meeting.

The list of sub-teams of 2 or 3 people and assignment for each team were posted on the CII SharePoint after the kickoff meeting. The task given to each sub-team was to

develop a first draft of a chapter of a potential the implementation resource by the next face-to-face meeting. Each of 9 sub-teams was responsible for each chapter of the implementation resource. The research summary also stated that nine sub-teams were formed to write the first draft of the implementation resource.

The team had a conference call meeting between the kickoff meeting and the second face-to-face meeting. The meeting minutes of this conference call noted that each sub-team reported the progress and outline of a draft. In the second face-to-face meeting which was about two months after the kickoff meeting, the 9 sub-teams made presentations of what they worked in front of the entire team. In the meeting agenda, each sub-team was assigned a one-hour presentation. In the third face-to-face meeting, each sub-team again made a 20-minute presentation to report the work progress.

This subgroup process shown in the meeting minutes during the first 6 months is consistent with what the interviewees recollected. Interviewee C described that the team spent the first 6 months where the team paired up contractors and owners and the sub-teams wrote a rough draft. This interviewee said that he "*remember very vividly doing this working"* with his partner who was a member from a contractor organization. He recollected that the team members actively exchanged ideas and discussed about what each of the sub-teams presented, which helped the team align stronger.

> "*The teams, how can I say, they were very aggressive challenging each other in terms of what we were doing with that..…… I believe it caused us to have much greater alignment because putting your work in front of 15 or 20 people that are experts really exposed the degree to which you understood things or the way you could present things and really brought out us where we were aligned"*

This interviewee thought that the core group of people emerged during the sub-team work process and they drove the research to the end.

> *"And from that point of that, there merged probably a core group about 10 or 11 people that kind of picked up leadership for each of those chapters or sections that were going on. Also, we started losing people because of the down turn of the economy right there. But, that really was the process that formed people that were going to drive the research and deliverables through the end."*

In regard to selection of sub-teams by the team members, the Interviewee A said that the industry members "*picked the sub-teams because they felt they had special expertise"*, which means that the team members chose their sub-team based on their domains of expertise. This is also found in the research report. The research report stated that team was divided into sub-teams according to members' "*expertise and interests"*.

Interviewee A thought that the sub-team approach *"worked very well"* and was *"very an effective way to get the final product"*.

> *"In a three-people team, they were better able to decide who should to what. It took the pressure off me and off the two co-chairs in trying to keep everyone busy. They kind of kept themselves busy."*

However, this interviewee added that having subgroups consistently write an implementation resource was effective for this team because the team members liked writing because of their expertise. Therefore, the interviewee wondered if it might or might not work for other group of people, for example a team with mostly construction managers or project managers.

Along with developing the implementation resource, the team members also reviewed and provided input to the case study interview guide and interview questions that had been drafted by the academics. Interviewee A said that it was because the team members *"were motivated to make sure we were collecting right data"* for the sections of the implementation resource that they were writing. The team members also participated in data collection by providing projects for case studies.

2.4.1.5 Factors for team participation and commitment

The research topic was commonly referred by the interviewees as a factor for team participation and commitment. According to the interviewees, the team members had *"a big interest in the topic"*, *"everybody recognized there was a problem"*, and people *"saw the need of the industry to do a study"* in this topic.

> *"I think it was the topic. People had a big interest in the topic. That's what they do, and they were eager to provide their expertise."* – Interviewee A

> *"I think the topic selection was very strong. It was just a very interesting study to be part of it. And, because of the willingness of everyone to contribute and be part of it, it just helped and enhanced the research being done."* – Interviewee B

> *"……We knew that this was the topic that people could benefit from.…… The motivation was that it was a real problem that all of us can contribute to."* – Interviewee C

Another factor could be relationships among the team members. This aspect was not directly mentioned as a factor for the team commitment by the interviewees. However, Interviewee B mentioned that the team was a *"cohesive group"* and *"respectful each other"*. Interviewee C also made similar comment about the team as below.

"I would say there was a great deal of respect built among the core team members as the project went on even though we didn't see each other very often. …… But, you could sense trust being built, after what I would call this period of proving what your experience was that you were then very well accepted."

Respect and trust built through the team process certainly seemed to play a positive role in team dynamics of this team.

2.4.2 Leadership

Key comments from the interviewees and the Post RT Survey respondents in regard to team leadership are listed Table M5-7 and Table M5-8, respectively.

2.4.2.1 Industry leadership

The industry interviewees recollected the original co-chairs were *"strong leaders"* and *"very involved in the beginning"*. However, both of the original co-chairs *"were gone at the end."* The contractor co-chair left the team because the co-chair's company discontinued CII membership, and the owner co-chair had job assignment overseas.

In spite of the fact that both of the original co-chairs did not participate on the team as co-chairs through the end, the performance of two original co-chairs was perceived differently by one of the industry interviewees. He viewed the original contractor co-chair as *"non-existent"* while the owner co-chair as a leader who *"collaborated real well"* with the lead-PI, *"took the lead"* and *"gave the team direction."* another industry interviewee said *"The chairs were less involved in leadership the longer went on."*

Interviewee A provided another perspective to the original co-chairs. This interviewee said that the co-chairs did not exactly know their roles and responsibilities.

"The chairs didn't know what to do and what their responsibilities were..…… One chair was not very effective at all. The other one, everyone liked him, didn't know what to do……I had a conversation with him, and he said that he didn't know what he was supposed to be doing as a chair. …… If he had more clear guidance, he would have been a great chair. ……He left the team for reassignment. Came back to the team in the last year and did a good job as a member…….What should really co-chairs be doing? What are they supposed be doing? Are they supposed to be driving participation or driving the alignment process? Because the co-chairs didn't do either one. That all seemed unclear on our team."

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Industry – contractor co-chair)	Interviewee C (Industry member)	Interviewee D (Industry member)
Leadership	• Mostly academic-led, especially after losing the original co-chairs.			
Chairs	• What should really co-chairs be doing? That all seemed unclear on our team.	• Didn't see any collaboration whatsoever between the [original] co-chairs at all.	• Once the team direction set, we had such a strong team and such an alignment. So, I don't think it was a problem that we lost them.	• The first chairs were strong, and the second chairs were kind of weak.
Chair Change	• Selected the new chairs strategically - close to the PI.	• January in the final year. The change process was seamless.		
Expectations established by chairs	• The chairs didn't know what they were supposed to do.	• [The owner co-chair] did. He did a good job. • [The contractor co-chair] had nothing to do with this team.		

Table M5-7: Team Leadership – Interviews

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Industry – contractor co-chair)	Interviewee C (Industry member)	Interviewee D (Industry member)
PIs		• [The lead-PI] was the glue. • [The lead-PI] was working with different segments and different individuals separately.	• The core team had a great respect for [the lead-PI]. • The PI used individuals effectively to help the team dynamic.	• [The lead-PI] kept us informed. • Very open and honest and hid nothing.
PIs & co-PIs	• [The co-PI] had own guide. • [The co-PI] dropped off after extension.	• [The co-PI] had an agenda and didn't try to align himself at all with what we were trying to accomplish.	• It was clear that there were two separate purposes.	• The other PI didn't participate much. • Not sure they [two PIs] were in alignment.
Leadership Communication	• Not really formal leadership meeting. • PI and Chairs typically didn't have meetings.			
Leadership Roles & Responsibility	• The new co-chairs really didn't have separate roles and responsibilities.		• Chairs: I don't know exactly what their responsibility was. • PI: keeping the team under control. The conductor of the orchestra.	• I am not sure that I understood the roles of co-chairs at the beginning

Table M5-7, continued.

Survey Question	Comments
The Principal Investigator(s) (team academic(s)) did a good job of structuring and facilitating this research.	• [The lead-PI] did an excellent job of keeping the team focused, on plan and schedule. • One of our researchers was much more involved than the other. The less involved individual had somewhat of a preconceived notion of the result which was not at all aligned with the team.
The Co-Chairs provided the expected leadership necessary for team success.	• The co-chairs on this project changed during the course of execution. This was not an optimal situation. • One Co-Chair dropped out of CII mid-stream and the other was relocated by their company overseas.

Table M5-8: Team Leadership – Post RT Survey

This lack of understanding in regard to chair roles and responsibilities does not seem to be only a co-chairs' problem. Interviewee D said *"I am not sure that I understood the roles of co-chairs at the beginning."* Interviewee C also made a similar comment which was *"From the industry chair point of view, I don't know exactly what their responsibility was."*

As the original co-chairs no longer participated on the team, the new co-chairs were selected. Two members were chosen because they *"were* [geographically] *close to* [the lead-PI]" as mentioned by Interviewee B who was one of the new co-chairs. This was consistent with what Interviewee A, the lead-PI, mentioned about selecting them as new co-chairs. Interviewee B said *"It* [chair change] *was seamless. There was no issues, no objections."* He recollected that the co-chairs changed *"probably in January"* of the last year, and he was not sure *"if it was even announced to the group."* The meeting minutes around that time did not note any official announcement of the chair change to the entire team. One of the Post RT survey respondents commented in regard to this chair change and leadership of the team as quoted below.

> *"The co-chairs on this project changed during the course of execution. This was not an optimal situation. At the start of the project, the co-chairs were aligned and drove the project. When they became less involved, the leadership fell to the remaining academic, who did a good job. The replacements were selected very late in the process and did not have the opportunity to effectively assume a leadership role."*

Interviewee A said *"All of the core people would have been good chairs."* According to this interviewee, the new co-chairs really *"didn't have separate roles and responsibilities"*. Interviewee B also said *"It wasn't any role or responsibility much other than to be there."* It is probably due to that the new co-chairs were selected when the team was finalizing their products and preparing for the conference presentation. Therefore, there might have been less demand for chair leadership as commented above by one of the Post RT Survey respondents.

Interviewee C thought that losing the original chairs was not a problem because the team was *"such a strong team"* and the team *"had such an alignment around what they were doing"* so they *"knew where they were going."* He added a comment that a two-year research team might not have turned out the same way. Along with this, he referred this team as holding strong group leadership with an implication that losing co-chair leadership was not detrimental to the team performance. He characterized this team as *"very self-operating"* in addition to the comments below.

> *"Very strong group leadership. I don't think, outside the first six months, or two or three meetings, that we were looking for the chairs to make decisions or keep people on a course. We knew what we were doing. That was only a matter of getting the work done."*

2.4.2.2 Academic leadership

On top of lack of industry chair leadership, the team had an alignment issue with the co-PI. The three interviewees commonly commented about this problem. Interviewee B thought that the co-PI had *"an agenda and didn't try align himself with the rest of the team."* One of the Post Research Team Survey respondents made similar comments as presented below.

> *"One of our researchers was much more involved than the other. The less involved individual had somewhat of a preconceived notion of the result which was not at all aligned with the team. In general, individuals in business and academia approach topics from a different perspective. The work performance and organization between the team and the remaining academic improved as time went on."*

Interviewee C recollected that *"it was very difficult at the beginning with the two academics because it was clear that there were two separate purposes"* and the team was *"trying to figure out which one"* to be working on. He said that the team did not think that the co-chair's purpose was in line with the research objective in the team charter.

The meeting minutes noted that the co-PI attended only 3 face-to-face meetings, and Interviewee A mentioned that the co-PI was not accepted as part of the team by the team. The co-PI eventually dropped off the team after the one-year extension was decided. It can be concluded that the co-PI neither actively participate in the research process nor maintain a good relationship with the rest of the team. The main reason might have been that the co-PI took a different approach to the research direction from that of the team.

On the contrary, the leadership of the remaining PI, the lead-PI, was perceived as effective by the industry interviewees and the Post RT Survey respondents. One of the Post Survey respondents described that the lead-PI *"did an excellent job of keeping the team focused, on plan and schedule."* Interviewee B characterized the lead-PI as *"the glue"* to bound owner side and contractor side together keeping the team moving forward.

> *"We had a good representation on the owner side and a good representation on the contractor side.* [The lead-PI] *kind of kept it together and moved it forward. I wouldn't give any other professor any credit because [the lead-PI] was the glue."*

Interviewee C described the PI's role in this team was keeping the team under control and informed of what was expected and what was next step. He characterized the lead-PI as an orchestra conductor.

> *"…… I think the role that* [the lead-PI] *played with was really keeping us under control first.* [The lead-PI] *laid out the whole process. …… So [the lead-PI] did a good job of being able to explain what was expected and how many people were going to participate, and when things had to happen.……* [The lead-PI] *had a good sense of what people were capable of doing and what they liked to do. So, I think* [the lead-PI] *found* [the new owner co-chair] *to take over for* [the original owner co-chair]. *……"*

> *"So, from roles and responsibilities, I kind of view* [the lead-PI] *as a conductor of the orchestra. After we got through the chaos, we decided what song we were going to play,* [the lead-PI] *was the person that kept everybody moving in the right direction so we could gain completion of the project."*

Interviewee D specifically mentioned about the communication of the lead-PI with the team. He said that the lead-PI *"communicated the research progress, results, hurdles, what went well and what went wrong, and issues"* and *"was very open and honest and hid nothing*." Another notable point that he made was the lead-PI *"was patient"* and *"didn't rush"* and made *"sure everybody was in alignment."*

According to the one of Interviewee B, once the lead-PI was *"accepted"* by the team members, the team member wanted to support the lead-PI.

> *"Once everybody was comfortable with* [the lead-PI], *everybody wanted to support* [the lead-PI] *and make this a good study. By the first two or three meetings, they accepted* [the lead-PI]. ……. [The lead-PI] *came to everybody's confidence, and everybody wanted to support* [the lead-PI]*."*

Interviewee C described in detail about the process of seeing and learning each other's value and building respect between the lead-PI and the team members.

> *"…… The group of people that she had on the team was very independent, self-sufficient group of people, which I think was a challenge for* [the lead-PI]. *I think* [the lead-PI] *learned a lot. We learned the value that* [the lead-PI] *brought to the process. …… I think the core team had a great respect for* [the lead-PI] *in terms of bringing that process forward."*

The lead-PI moved to a different institution during project period. However, it did not seem to affect performance of the lead-PI the team. Only one of the 3 industry interviewees mentioned about this transfer. Interviewee B thought the change of the graduate students was not a problem.

> "[The lead-PI], *who actually transferred universities during the course,……was there from day one and kept things together. ….…* [the lead-PI] *was always well prepared. We shifted graduate students during the course. I don't think that caused any problem."*

It can be concluded that the lead-PI was the center of the leadership of this team under the circumstance where there were weak industry leadership and misalignment and lack of involvement of the co-PI. The lead-PI kept the team focused and moving forward toward. In addition, the lead-PI was good at assigning roles and tasks to people so that people could continuously participate and engage according to Interviewee C.

It is likely that the subgroup approach adopted up front helped the lead-PI manage and lead the team when collaboration from the industry chairs was not much provided in terms of leadership. Support and respect of the team and the core group of about 10 people also could be important factors that helped the lead-PI lead the team and complete the research as Interviewee A mentioned as below.

> *"The core group of people we ended up with was great to work with. They were willing to work hard, they were knowledgeable, and if I needed something then it was easy to get it."*

To the Post RT Survey question 'The Co-Chairs provided the expected leadership necessary for team success', 3 survey participants responded 'Agree', 3 did 'Neutral', and 2 did 'Disagree' on a 5-point scale from a total of 8 survey participants. To the question 'The Principal Investigator(s) (team academic(s)) did a good job of structuring and facilitating this research', 3 responses were 'Strongly Agree', 4 were 'Agree' and 1 was 'Neutral'. The respondent who rated 'Neural' to this question commented about the less involvement and misalignment of the co-PI. All of 8 respondents rated either 'Strongly Agree' (2) or 'Agree' (6) to the question 'The academic support (development of methodology, facilitation, data analyses, meeting support, etc.) was appropriate and met my expectations.' Based on these results, it is a probable conclusion that the team members were more satisfied with the lead-PI's performance than the chairs' performance.

The Post RT Survey results were consistent with what the interviewees responded to leadership questions. The academic interviewee said that the team was "*mostly academic-led, especially after the team lost the original co-chairs."* Considering the fact that both co-chairs changed and the co-PI withdrew the team, it is highly possible that the leadership of this team was more put on the academic side which is, more precisely saying, the lead-PI. The leadership of this team will be further discussed in the following section from the industry leadership and academic leadership perspectives.

2.4.3 Team relationship and communications

Key comments from the interviewees and the Post RT Survey respondents in regard to team communications are listed Table M5-9 and Table M5-10, respectively.

2.4.3.1 Team relationship and conflicts

Besides the alignment issues with the co-PI and a couple of opinionated members during the scope alignment period, the team had conflicts within neither the whole team nor subgroups. Interviewee C recollected that *"there was a great deal of respect built among the core team members as the project went on",* and most members *"were very open to get in a role."* which the interviewee thought was good.

2.4.3.2 Team meetings

The meeting frequency of this team was every month altering face-to-face meeting and teleconference meeting. The team had 11 face-to-face meetings and 14 teleconference meetings during the total project period of 34 months. They had face-to-face meetings every 2 months during the first 10 months and about every 4 months afterwards.

When the team was approved 1 year of extension in the early second year (about 15 months after the kickoff meeting), and consequently the team members learned they would not report out in 6 months, the member participation became lower until the final year started, according to one of the industry interviewee. He also pointed out that the PIs and several other members conducted during that middle period, which brought less workload to the other team members. As a result, the face-to-face meetings of the whole team were less frequent and shortened to a full-day meeting from one and a half day meeting. This interviewee thought that the team could be *"relaxed"* and had *"a good break"* during that middle period.

A face-to-face meeting typically started with review of the schedule and progress, followed by the report on the case study progress and analysis, update and review of the IR, and concluded with the review of future schedules. Meeting agendas were prepared by the lead-PI, and the lead-PI communicated the meeting agenda with every team member beforehand so that the team members *"could make suggestions"*.

The lead-PI prepared presentation slides for each meeting – both face-to-face meetings and conference calls. The lead-PI did not recollect any formal leadership meeting in preparation for the team meetings. The meeting notes were taken and kept by the graduate research assistant of the team and posted on the CII SharePoint. The team utilized the CII SharePoint to an extensive degree posting every document that the team produced for sharing and review purposes.

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Industry – contractor co-chair)	Interviewee C (Industry member)	Interviewee D (Industry member)
Team Relationship		• Cohesive group – respectful each other.	• There was a great deal of respect and trust built.	
Conflicts	• No conflicts within sub-teams.	• No conflicts. Good relationship.	• Some personality conflicts, no value conflicts	
PIs & Industry members	• It got better as time went on.	• Once everybody was comfortable with [the lead-PI], everybody wanted to support [the lead-PI].	• [The lead-PI] did a good job of making sure that people wanted to participate had some defined role to keep them involved in the process.	• The PI communicated the research progress, results, hurdles, what went well and what went wrong, and issues.
Team Meetings	• Academic led the meetings. • The graduate student kept the meeting notes. • Communicated the agenda with everyone.	• The graduate student taking meeting notes.	• Agenda set by the PI - leader of the agenda during the meeting.	

Table M5-9: Team Communications – Interviews

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Industry – contractor co-chair)	Interviewee C (Industry member)	Interviewee D (Industry member)
Team Communications	• Four face-to-face meetings per year. • Conference calls every month. • CII SharePoint.	• Face-to-face meetings every two months and interim teleconference.	• Quarterly face-to-face meetings.	
Social Activities	• Team dinners	• Team dinners	• Team dinners	
Team Operation & Management	• Everybody looked at everybody else's work.	• The team was self-functioning and self-leading. • [The lead-PI] was there to keep that forward movement going.		

Table M5-9, continued.

Survey Question	Responses	Comments
The research team was properly aligned throughout the project.	• A total of 9 responses • 'Strongly Agree' – 5 • 'Agree'– 4	• There was misalignment between one academic and the team. In general, there was good alignment between the team and academic that remained at the end of the project.
The research team got off to a good start.	• A total of 8 responses • 'Strongly Agree' – 4 • 'Agree' – 4	• The high level topic was good and there was a high level of participation and enthusiasm.
The research project plan and schedule were communicated and agreed to before significant work began.	• A total of 8 responses • 'Agree' – 8	• The methodology was clear and there was significant involvement by the team members in generating the structure of the implementation resource before the detailed work began. • Would comment that the research direction evolved as we moved to develop questionnaire and through the case study.
What was the research team meeting frequency (both face-to-face and by phone/web?)	• A total of 8 responses • "Strongly Agree" – 4 • "Agree" – 4	• Face to face we met every three months and had phone/web meeting on the in between months. • Quarterly face to face and monthly by teleconference • Every other month, alternating between face-to-face and teleconferences. • Monthly teleconferences ad quarterly face-to-face meetings.
The research team meeting frequency (phone, web, face-to-face) was appropriate and efficient.	• A total of 8 responses • "Agree" – 7 • "Neutral" – 1	

Table M5-10: Team Communications – Post RT Survey Responses

One example of the lead-PI's meeting preparation was pre-work before the kickoff meeting. The kickoff meeting presentation slides of this team showed that the lead-PI conducted a team survey with regard to the topic prior to the kickoff meeting and presented the survey results to the team at the kickoff meeting. The research report stated that this initial survey results formed a basis for a team to identify case study selection criteria. The lead-PI also prepared important elements of the topic which would be sections of the IR and sub-teams would be working with.

The responses of the Post RT Survey with respect to team communications were all positive without any neutral or negative responses (i.e., 'Neutral', 'Disagree', 'Strongly Disagree'). The research plan and methodology were also clearly communicated with the industry members according to the survey responses.

2.5 PRODUCT DESIGN AND DEVELOPMENT

Key comments from the interviewees and the Post RT Survey responses in regard to research products are listed Table M5-11 and Table M5-12.

All of the interviewees perceived their research products as *"well done"* and *"providing good information"*. One of the industry interviewees said that the team was clear about its product that they would not develop a tool. This was one of key directions given in the research topic statement by the CII. The proposal submitted to CII by the PIs stated that this research would develop a manual. According to one of the interviewees, the team reached consensus to develop an *"easy-to-use, practical, and friendly"* guide from the early phase of the process.

According to the academic interviewee, the team had a lengthy debate in regard to identifying the target audience for their implementation resource and what the final product would be because of one of opinionated members.

> *"……One of them* [two opinionated people] *thought that the target audience should be more experienced and senior level people. The rest of the team didn't, so that was the biggest disagreement.……Because we had so many difficulties to identify who the target audience would be, there's a lot of disagreement on what the product should be. After they dropped off, the team agreed that the target audience should be…… The team made consensus on the final product pretty quickly after that."*

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Industry – contractor co-chair)	Interviewee C (Industry member)	Interviewee D (Industry member)
Product Quality	• Pretty good. • Provides good information.	• Well done. • Pretty thorough. • Clearly set the target audience early on.	• The product was good.	• Our goal was to write a guide.
Key Considerations	• No. 1 consideration was target audience. • No. 2 consideration – explaining the difference.		• Target audience • Format • Level of the material (high level)	• A consensus from the very beginning – to develop an easy-to-use, practical, friendly guide.
Industry Member Involvement	• Writing up the research products	• Starting writing and putting those together at least by the midway through the process	• Two or three person groups - 6 months working	
Implementation Tool	• The CII RC forbad the team from creating a tool. They told to do case studies.	• I don't know the tool would be necessary for this type of topic.		
Feedback	• No feedback from industry people. • Two conf. Papers - academic feedback was good	• Not that I know of. • Don't think there is a need for a further study.		

Table M5-11: Product Design and Development – Interviews

Survey Question	Responses	Comments
The research project deliverables (Research summary and Implementation resource, if appropriate) were most suited to improve performance of CII member companies.	• A total of 9 responses • 'Strongly Agree' – 3 • 'Agree' – 4 • 'Neutral' – 1	
The topic and research conducted were consistent with what I initially expected.	• A total of 8 responses • 'Strongly Agree' – 2 • 'Agree' – 4 • 'Neutral' – 1 • 'Disagree' – 1	• The depth of the research and level of the implementation guide were less than I expected. This had more to do with the focus on less experienced personnel than I anticipated.

Table M5-12: Product Design and Development – Post RT Survey Responses

The development of the implementation resource was the co-production of the entire team where the experience of the team members was collectively incorporated through sub-team writing-up of each section. After reviewing each other's work and revising, the consolidated implementation resource was rewritten by one of the core members, mentioned as a *"superstar"* by the academic interviewee, who had extensive experience and knowledge with regard to the topic. The purpose of this process was to have the implementation resource look more seamlessly and consistent and read like written by one author. One of the industry interviewees mentioned about this process as below.

> *"….people had a lot of confidence in* [the rewriter]*…… People trusted* [the rewriter] *that he knew what was going on and he knew what their opinions were. And when he went through and redid everything, I don't think there are a lot of changes made to that."*

This interviewee also pointed out that this approach showed that the lead-PI *"used individuals effectively to help the team dynamic"*.

Whereas every team member participated in writing the implementation resource throughout the research period, the research summary was written by a few people when

the rest of the team members were preparing on the presentations for the conference in the final year. The team submitted both the research summary and the implementation resource by deadlines and resubmitted both after incorporating the CII Product Review Board (PRB).

Interestingly, Interviewee B said that he was confused the implementation resource with the research summary. Since his perception was that only research product required by CII was research summary, so he thought that what he was writing was the research summary. When he realized that what he was writing was *"going beyond the perimeters CII wants"*, he talked to the lead-PI and he then knew it was actually the implementation resource not the research summary adding that it was his *"bias from the past team."* He also commented that he had *"never seen like this Implementation resource in implementation sessions" and "it's always been flowcharts or tools."*

The responses of the Post RT Survey were generally positive, except one respondent answered "Disagree" to the question 'The topic and research conducted were consistent with what I initially expected'. From his comment provided in Table 2-10, this respondent was not satisfied with the target audience of the research products. This aspect was mentioned by Interviewee A as one weakness of the team. The interviewee recalled that there were *"a couple of opinionated"* members on the team, which caused a difficulty in alignment. The interviewee further elaborated that one of those two members insisted that *"the target audience should be more experienced and senior level people"*, which the rest of the team did not agree.

> *"After they* [the two opinionated members] *dropped off, the team agreed that the target audience should be new comers or mid-level or people with less experience in reimbursable contracting.…The team made consensus on the final product pretty quickly after that."*

The CII product download records indicated that the research summary of this team was among top 10 most downloaded CII products of the year the team reported out. The combined download number of the research summary and implementation resource of this team was in the top 5 among research teams. In terms of the combined rating of the plenary session and implementation session of the Annual Conference Survey that was rated by the conference attendees, this team was not highly ranked among the 5 research teams that reported out same year.

Appendix M6

Individual Case Description Report

Distinguished Case: D3

Table of Contents

List of Tables

1. Introduction

1.1 CASE INFORMATION

Table M6-1 summarizes the overall information of the case D3.

Case Category	Distinguished		
Project	Project period	Total 2 years	
	kickoff date	Mid-October	
Industry Chairs	Number of chairs	2 co-chairs	
	Change in chairs	No	
	Previous CII experience	No	
Principal Investigators (PIs)	Number of PIs	2 PIs	
	Change in PIs	No	
	Previous CII experience	No (lead-PI) Yes (co-PI)	
Team members	Number of members (excl. academics)	Kickoff: 16	Owner: 8, Contractor: 8
		Report out: 16	Owner: 6, Contractor: 10
	Number of industry members with previous CII research team experience (excl. chairs)	0	
Research Methodology	Research Method	Survey	
	Validation Process		
Products	Products published	Research Summary: 1	
		Implementation Resource: 1	
		Research Report: 1	

Table M6-1: Case Information

1.2 DATA SOURCES

The main data source for this case study was individual interviews with 2 academics and 4 industry members of this team. Other data sources to support and/or supplement the interviews included CII Post Research Team Survey (Post RT Survey) responses of this team and CII documents and archival records. The detailed data sources and their availability for analysis are summarized in Table 1-2. All the available sources

in Table M6-2 were analyzed to investigate the case from multiple perspectives. Words, phrases, and sentences in italic font with quotation marks in this case description indicate direct quotes from the interviews or comments of the Post RT Survey respondents.

Data Type	Data Source		Available and used for analysis
Interview	6 interviews	2 academics	
		4 industry team members	
Documentation	Team documents (retrieved from CII SharePoint)	Research Topic Statement	Yes
		Proposal	Yes
		Charter	Yes
		Meeting agenda	No
		Meeting minutes	7 meeting minutes (6 face-to-face meetings and 1 conference call meeting)
		Interim Reports	Yes (two reports)
		Team roster	Yes (as of kickoff, halfway, reporting out)
	Research products	Research Summary	Yes
		Implementation Resource	Yes
		Research Report	Yes
Archival Records	CII surveys	CII Post Research Team Survey	Yes
		Annual Conference Evaluation Survey	Yes
	CII records	CII product usage - Hardcopy sales and e-copy downloads numbers	Yes

Table M6-2: Data Sources

1.2.1 Interviews

For this team, 6 team members were interviewed; the lead-PI and the co-PI, and 4 industry team members. One of the 4 industry team members was the owner co-chair of this team. Only the co-PI interviewee had prior CII research experience, and the lead-PI and the 4 industry interviewees did not have any previous CII research team experience. Each interview was conducted on a one-to-one basis at a different time and place. Interview durations ranged from 1.5 to 2 hours depending on interviewees' time

availability. Dialogues of all 6 interviews were digitally voice-recorded upon the written consent of the interviewees.

1.2.2 CII Post Research Team Survey (Post RT Survey)

A total of 7 industry team members of this team responded the Post RT Survey. The Post RT Survey is sent by CII to every CII research team member after the team reported out at a CII Annual Conference. The survey analysis considered the ratings and comments that the respondents provided in a narrative form. Since the survey respondents were less than half of the entire team, any statistics on the respondents' ratings based on a five-point scale were only regarded as referential.

1.2.3 Other data sources

Other data sources collected and reviewed for this case were team documents and CII archival records relevant to this case. The team documents included the research topic statement provided to this team by CII, the proposal submitted by the PIs to CII, the team charter, meeting minutes, team rosters, interim reports submitted to CII by the team, and the research products that the team delivered (i.e., research summary, implementation resource and research report). The CII archival records included CII Post RT Survey responses, CII Annual Conference Evaluation Survey ratings, and hardcopy sales and e-copy downloads numbers of the research products of this team.

2. Case Analysis

2.1 CASE INFORMATION

The team started with a kickoff meeting in mid-October with a target report out date in 21 months. The research topic statement was provided to the team with an essential question and potential deliverables. In the kickoff meeting, the team drafted a team charter that included background, definition of the topic, purpose, objectives, limitations, specific deliverables and norms.

This team did not experience any leadership changes. The two co-chairs and the two PIs stayed until the end of the research. Both co-chairs had no prior CII research team experience. The lead-PI, who was a junior faculty member when started this research, did not have previous CII research team experience either, whereas the co-PI, who was a senior and experienced faculty member, had served on multiple CII research teams. Both PIs had civil engineering backgrounds specializing in construction management. They were in the same program at the same institution at the time of the research.

Initially there were 16 industry team members plus 2 PIs and 1 graduate research assistant according to the attendee list of the kickoff meeting minutes. Owner members and contractor members were evenly distributed. Half of the initial 16 members were in manager or director positions, and four members were in a senior executive level, either president or vice president positions. The final team members, listed in the research summary of this team, were 18 excluding 2 academics and 1 graduate research assistant. This number is inconsistent with that of the team roster as of the team's report out. This last roster of the team listed 16 industry members. One of the 2 additional members shown in the research summary did not participate in any of the team meetings, and another participated in only the kickoff meeting. This is consistent with the co-PI interviewee's response to team attrition; *"a couple of people never participated"*. He was looking at the team members listed in the research summary when he made this comment adding "*while they are listed here, really they shouldn't have been."*

For the meeting minutes, 6 face-to-face meeting minutes and one conference call meeting minutes were available for analysis. The total number of meetings including face-to-face meetings and conference call meetings was unknown since the meeting minutes of the last 10 months of the research process were not available. Based on the attendees and absentees listed in each meeting minutes, the average number of face-to-face meeting attendees was 11 with an average meeting attendance rate of 68%. The team had a face-to-face meeting every 6 to 8 weeks during the first year.

2.2 STRENGTHS AND WEAKNESSES

Table M6-3 includes key responses of the interviewees to the question asking about strengths, weaknesses and/or challenges, and unique aspects of this team. The key strengths that were commonly noted by the interviewees included good team dynamics and participation, committed chairs and good facilitation from the academics including a graduate research assistant. First, the interviewees noted that the team was *"diverse"* with a *"good mix of owner and contractors"*, and the members were *"experienced"* with *"complementary"* backgrounds. The team also exhibited *"strong participation"* and *"consistency"*. Second, the two co-chairs were *"committed" and they were "good leaders"*. Third, the academics provided *"good facilitation"*, the two PIs were a good combination of *"experience"* and *"newness"*, and the graduate student was *"outstanding"*.

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Academic – co-PI)	Interviewee C (Industry – owner co-chair)	Interviewee D (Industry)	Interviewee E (Industry)	Interviewee F (Industry)
Strengths	• Diversity of industry. • Two committed co-chairs. • Senior faculty, junior faculty, and an excellent research assistant. • Experienced team.	• Participation and engagement. • (The team) had different contributions to make. • Good mix of owners and contractors. • Excellent co-chairs.	• Good team. • PIs - experience and newness played well together. • GRA was outstanding. • Consistency of the team. Strong participation.	• Fairly even representation of owners and contractors. • Fairly outspoken group of people. • Academic facilitation.	• Excellent participation. • Willing to challenge the process. • There was a desire from everyone [for the research].	• Lead-PI – good leader. • GRA. • Very good team chemistry. • Good mix of owner, contractor and supplier. • People's backgrounds were complementary.
Weaknesses / Challenges	• There was always a concern that we are going to be late with the deliverables.	• One member was a little bit difficult to work with. • Topic - difficult to define and determine how to address.	• Clearly slow start. • The first meeting was very inefficient. • Did not do a good job of integrating or utilizing past research and existing products of CII.	• The problem statement - fairly broad. • We spent 6 to 8 months trying to figure out what the real problem was. • The economy was not good at that time.	• Downturn in the economy. • Tried web meetings, but not everyone even had web capability.	• The biggest challenge was participation and getting everybody together because everybody was busy.

Table M6-3: Strengths and Weaknesses – Interviews

In addition to the strong participation and engagement of the team members, Interviewees B and D particularly mentioned that the members were *"fairly outspoken"*. The team *"did not have folks who did not speak up in meetings"* and *"all had contributions to make"*. These members did *"not mind speaking their opinions even if their opinions were controversial."* Therefore, the team atmosphere was *"open"* and the members shared ideas. Interviewee E recalled that they *"had a very vocal group"*. The *"team members were willing to challenge the process"* in order to make sure that they *"were meeting the intent of the essential question"*. This interviewee also said that *"there was a desire from everyone just to produce research that wouldn't be contested by others in the industry"*.

Interviewees A and B, the two academic interviewees, commonly viewed the co-chairs as one of strengths. Interviewee B further commented that *"the rest of the team respected those two"*, and the academics *"were willing to support what they* [the co-chairs] *did, and both of them* [the co-chairs] *helped and supported"* the academics. The co-chairs as well as the academics including the graduate student of this team were regarded as strengths by multiple interviewees.

Interviewees A and C commented about the mix of the two PIs. Interviewee A thought it was strength to have a mix of academics – a senior faculty member who was familiar with the CII process, the graduate research assistant who had industry experience, and the lead-PI, the interviewee himself, who was familiar with research in different areas even though it was his first CII research. Interviewee C commented about the advantage of having an experienced PI and a newer PI as noted below.

> *"Experience of the co-PI was the key component. Inexperience of the lead PI was a key positive factor – a lot of energy and willingness and desire to succeed. Inexperience was not a detractor. Those two combined, experience and newness, or inexperience played well together."*

Interviewee D thought the industry was *"driven to the solution"*, but the academics slowed down this industry tendency of directly going into a solution as shown below.

> *"We* [industry people] *are driven to the solution. I think that the way that the team was set up with academic facilitation, it slowed the process down a little bit, but it provided questioning.……It required academic curiosity and searching to really look at the problems from all angles and provide real solid solutions versus automatically guiding to an answer."*

Weaknesses or challenges referred by the interviewees included a broad topic, schedule pressure, and economic downturn. Interviewees B and D both mentioned about the difficulty of defining the scope for the given topic. Interviewee B said that the *"topic*

itself was a challenge" because it was characteristic of recent CII research topics that are *"a bit more difficult to define and determine"* how the team should address. Interviewee D said that the problem statement was *"so broad"* and *"almost overwhelming"*. As a result, he said that it took the team a *"long time to really get to the problem statement"*. He thought that the team *"could have done a bit more homework before engaging as a team to narrow the topic"* because the team *"spent six to eight months trying to figure out what the real problem statement was and what the real opportunity was"*.

Interviewee C, one of the co-chairs of this team, had a similar notion. He first identified the *"slow start"* of the team as a weakness saying that the team spent *"the first few meetings developing the charter and the research plan."* What differed from Interviewee D and Interviewee C in perceiving this *"slow start"* was Interviewee D thought that this long period of scoping *"could have been by design"* since the industry is *"solution-oriented"* and tends to *"go to the solutions sometimes too quickly"* unlike academics who *"build a slower process"*, while Interviewee C viewed it as *"inefficient"*. Interviewee C further elaborated his opinion as quoted below.

> *"The first meeting was very inefficient. Developing the team's project plan was very inefficient due to unclear roles and responsibilities, and, I personally think, developing the charter and the project plan with the full team is very inefficient and a bad idea."*

> *"Most people participating on CII research teams have experience in a project-type environment…… In a project environment, people understand that some people are more equal than other. And,* [some] *people seek, desire, and be happy to concede to leadership.* [Some] p*eople are happy to be told what to do……Instead, we were all trying to develop consensus."*

He made a suggestion concerning this issue that he thought inefficient as shown below.

> *"If a small team of maybe just the PIs and co-chairs and maybe one or two others had spent two days developing a* [near] *final draft charter and a 2-year plan, and then, the whole team got together, they presented it, and revised it. ……that would have been more efficient."*

This issue was also reflected in the comments from Interviewee A. He recollected that *"there was always a concern"* among the team that the team was *"going to be late with the deliverables, especially with a couple of meetings without making any visible progress although there was a lot of progress in understanding the bigger picture."*

Another weakness noted by Interviewee C was the difficulty in defining where their research would fit into the CII Knowledge Structure. He said *"we spent at least a*

half of a full meeting trying to understand and define where the topic fit in the CII process of project management and what tools project managers use before our tool and after our tool." He suspected that this was *"true for many CII projects"*. He thought that this issue was important in two aspects; one was from the perspective of efficiency and effectiveness of the research team, and the other was from the perspective of users of CII products.

> *"I suspect that this is true for many CII projects. CII has over the course of two decades developed a total program of project management. Many of its research teams developed a subset of the program. If we were to be explained how we fit into that outfit of the program* [CII Knowledge Structure], *it would make it* [their research effort] *more efficient and effective.…… The team would understand how it fit into the knowledge structure and, therefore, they may go to and review the products that may precede or follow their work at that point – one third point (of the research process). They can study the previous and succeeding work, and they would define how their product is going to add ultimate value. Therefore, their product will become better."*

He proposed that *"CII should work with the team or team leadership to align where the product of the research team is going to fit into the Knowledge Structure, maybe by the end of one third of the process."* He acknowledged that there would be *"a counterargument from academics"*, which was that would *"restrain or put too much direction on research and it would inhibit free flowing of ideas"*. However, he thought that it would be okay to put some boundaries. However, he added that *"the whole body of knowledge of CII knowledge structure is greater than sum of the parts, and it is valuable having the parts"*.

2.3 RESEARCH METHODOLOGY

Key comments from the interviewees in regard to research methodology are listed Table M6-4.

2.3.1 Scoping

According to the interviewees, the team spent 6 to 8 months to scope out their research. During this initial phase of the research, the team tried to understand *"the problem"* and what the team was *"really trying to do"*. The team also *"spent a lot of time"* to define terminology and definitions for the research. A couple of interviewees felt that the scope did not change much once the team was aligned.

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Academic – co-PI)	Interviewee C (Industry – owner co-chair)	Interviewee D (Industry)	Interviewee E (Industry)	Interviewee F (Industry)
Scoping Phase – Alignment	• It took three or four meetings. • It took us a while to understand the problem.	• A couple of months to try to understand what it was what we were really trying to do.	• Spent an awful lot of time to define terminology and to get aligned.	• 6~8 months • PIs - keeping us from jumping to the conclusions. • Had to go back to the original team charter a couple of times.	• At least 6 or 8 months. • Spent a lot of time on definitions.	• Spent lots of time to define and develop definitions and clear statements. • The team was aligned around the charter.
Scoping - Change	• It didn't change much.			• I don't think we deviated much.		
Scoping - Industry Background Study	• Homework including data collection.	• We did have them do some exercises.	• We did some, but not much.		• Individual homework – survey & definitions	• Did homework and tasks and internal survey.

Table M6-4: Research Methodology – Interviews

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Academic – co-PI)	Interviewee C (Industry – owner co-chair)	Interviewee D (Industry)	Interviewee E (Industry)	Interviewee F (Industry)
Data Collection & Analysis – Data Collection	• Survey method	• Survey method	• We did an average or above average job.	• I don't think we had data gathering and methodology identified in front-end.	• Two different surveys. • I think it sort of kept evolving.	
Data Collection & Analysis – Challenges	• To have statistically sound results given a small sample size.	• The response wasn't as much as we would like to have.	• The process of getting volunteers was challenging.		• Sample size • Whether it covered all market sectors in CII.	• [Find] people who engaged in past project for data collection.
Data Collection & Analysis – Industry Roles	• [Industry members] collected survey data.			• Had to go back to our companies and collect data.	• Individually, we did go out and collect surveys.	

Table M6-4, continued.

Interviewee E referred this scoping phase as *"wandering period"* where the team *"continually going back to the essential question and trying to figure out what the question really was, what the scope entails."* Interviewee F said that the team *"tried to understand the commonalities across different project types and organizations"*. Interviewee D characterized this scoping process as *"a good exercise and healthy"* and *"interesting"*. He also mentioned that the team *"had to go back to the original team charter a couple of times to make sure"* that their *"plan forward was consistent with the problem statement."* Interviewee A said that the scoping was *"essential"* even though it took the team a while to understand the problem. Interviewee B also mentioned that getting *"everyone to understand"* what the problem was and what the team was trying to do was *"the biggest issue"* during the initial phase.

The minutes of the kickoff meeting noted that the team developed their charter and work plan after they discussed the research topic statement and the proposal. In the following meeting, which was a conference call, the lead-PI presented the *"team questionnaire"* to *"develop the survey and enumerate"* topic related terms and definitions. This *"team questionnaire"* shown in the minutes of this conference call meeting was what Interviewee F referred as *"initial survey"* or *"internal survey"*, one of the two surveys that the tem conducted. The team agreed to send their responses to the PIs before the second face-to-face meeting. In the second face-to-face meeting, which was about two months after the kickoff meeting, the team reviewed the results of the internal survey, and each member was assigned to define *"a few terms"* before the next meeting. Besides, three industry members presented their case studies related to the topic, and the co-PI also *"gave a presentation on a few current CII tools"* during this meeting.

The team *"broke into two groups and reviewed the definitions and revised, where necessary"* and generated a *"final list"* with *"team consensus"* as noted in the third face-to-face meeting minutes. In this meeting, the team discussed development of a survey, which would be sent out to CII member companies and non-CII companies, if possible. In addition, the team changed the team charter and methodology *"due to change of tool approach"* that was discussed in the second face-to-face meeting.

Interviewee C said that the team *"spent an awful lot of time to define terminology and to get aligned"*. Interviewee E also commented that the team *"spent a lot of time on definitions"*. This interviewee added that the team did not recognize some definitions because *"some of those definitions might have been already developed in CII."* The team *"came up with our* [their] *definitions"*, and they *"spent a lot of time going through those and hashing it out getting to*[what] *we* [the team] *thought was the right definitions to use for survey"*. These definitions, which the team developed and defined, are included the research summary, the implementation resource, and the research report as an appendix.

The industry members did individual tasks during the initial phase in regard to developing a list of definitions as described above. The members did *"a pretty simple survey"* to *"capture"* topic related terms and issues and worked on *"maybe five*

definitions" which they *"brought back in"* for the whole team to review. Interviewee A said that they *"got the industry members engaged through some sort of homework including data collection"*. Interviewee B thought that the industry members *"helped make that part of research more valuable to industry because they actually developed descriptions"* of topic related definitions. In addition, as described above, 3 industry members presented case studies in relation to the topic in the second meeting. However, according to Interviewee A, the industry members were not given any separate reading assignments.

Interviewee C recollected that the members did some background studies but not much compared with the current team on which he is participating. He, then, provided four benefits of industry members doing background studies from his perspective.

> *"Depending how it is done, first, it can be for alignment of a team, second, it provides knowledge of terminology, third, a team can know what has been done, and fourth, it can help identify the gaps and areas where a team can fill in."*

2.3.2 Data collection

The data collection method of this team was a survey approach. Based on the data collected, the team developed a tool through modeling, as stated in the research summary and research report. A draft survey prepared by the academics was discussed in the fourth face-to-face meeting, which was about 6 months after the team started, and a couple of the team members conducted a pilot test of the survey during this meeting. The survey was distributed before the fifth face-to-face meeting. The minutes of the sixth face-to-face meeting, which was to be 2 months later according to the fifth meeting minutes, was not available for analysis. The second interim report that the team submitted to CII one year after the kickoff meeting noted that the *"survey was distributed with the assistance of CII data liaisons and"* a non-profit organization in construction. This interim report also discusses the analysis of data collected through the survey.

Table M6-5 shows the Post RT Survey responses for this team to the questions related to data collection. Among seven respondents, no one responded 'Disagree' or 'Strongly Disagree' to the questions related to data collection of this team. The survey respondents perceived their data collection efforts positive in general. However, in terms of the data amount, some survey respondents also thought they had difficulty in obtaining enough data.

Survey Question	Responses	Comment
The team had an appropriate and well organized data collection plan.	• A total of 7 responses • 'Strongly Agree' – 3 • 'Agree' – 4	• Pretty good survey - but would've been better w/ more member company participation.
The data collection plan was well executed.	• A total of 7 responses • 'Strongly Agree' – 2 • 'Agree' – 4 • 'Neutral' – 1	• Would've been better with more member company participation. • There was a good plan and the CII team provided the proper amount of encouragement to get the data. [The graduate research assistant] did an outstanding job facilitating this phase of the project. • Could have improved amount of data collected with more direct collection. • I believe the approach of utilizing the typical entry points to the CII member companies through the CII representatives supplemented by having the team members approach the appropriate members of the Company staffs worked well.
There was strong CII member support in the data collection effort.	• A total of 7 responses • 'Strongly Agree' – 1 • 'Agree' – 4 • 'Neutral' – 2	• I don't think we got the number of survey responses back that we expected, and a high percentage of the responses we did receive came from the companies who had a member on this team. • I expected that we would get stronger input (more surveys back). We did not, however, set a target number of responses/demographic in advance. • The number of projects received represents, I believe, a strong response but not as great as we were attempting to reach.
The quality of data collected and overall research met my expectations.	• A total of 7 responses • 'Strongly Agree' – 3 • 'Agree' – 4	• I think the overall research resulted in a good tool for discussion that could potentially be adapted in some form by my company. • We were focused almost too much on schedule early on, and perhaps should have worked a bit longer on [topic related] definitions and structure of survey before releasing it.

Table M6-5: Post RT Survey Responses – Data Collection

The interviewees commonly perceived the *"sample size"* as a challenge in data collection. Interviewee C thought that the team *"did an average or above average job"* in data collection. However, he added that *"the process of getting volunteers was challenging"*. Interviewee D also commented that *"the biggest concern we* [the team] *had all along was the survey sample size"* as well as *"whether it covered all market sectors in CII" since the team "probably didn't have anything from the building sector"*. Interviewee A said that they *"had to make the best use out of data"* since *"it wasn't sufficient for"* a certain type of methodology, such as the one they used.

The data amount issue was also mentioned by several respondents of Post RT Survey. The respondents thought the amount of survey data that the team received did not meet what the team expected. One respondent suggested using *"direct"* and *"personal connections"* from team members for sending out the initial survey request could have improved this issue. Interviewee C made a similar comment in regard to the data collection process. He said that CII *"Data Liaison"* was *"a good theory, but in reality, it doesn't work effectively"* where as *"the process of having CII approve the data collection plan is a good one."* Apart from data amount, other several respondents pointed that the data collection plan and approach was *"good"* and *"worked well"*.

Another aspect of the data collection of this team was that the team attempted to collect data outside CII reaching out to another construction organization. According to the research summary and the research report of this team, only two responses were collected from this organization. Interviewee B said that the team *"didn't have much success with"* that organization, and he felt that it was a *"disappointment"* because he thought that *"they would participate more than they did."*

2.3.3 Research methodology change

One attribute of the research process of this team that emerged from the interviews was *"evolving"* of research methodology. This *"evolving"* attribute was mentioned by several interviewees to refer shaping research methods including data collection and tool development as the research progressed. When asked if there were any newly added or changed ideas to the original proposal by the team members, Interviewee A answered as below.

> *"Well, in the proposal, I kind of had an idea, and that evolved throughout these [the first] three meetings. So, there were at least three or four methods we could have used. Uh, there was no particular one that I really wanted to push, but one came out as the best, satisfied all the requirements from the scope. That one fitted most."*

When purpose and objectives of this proposal submitted to CII and those of the final charter of the team were compared, some wordings of the purpose changed, and the objectives completely changed in the charter. In terms of research methodology, data

collection methods also changed from more qualitative ones to a quantitative one. The third face-to-face meeting minutes records that objectives of the charter and methodology changed since the second face-to-face meeting. A survey approach for data collection was also discussed in the minutes of this meeting. It was consistent with what Interviewee E said about the research methodology. This interviewee perceived that their research methodology was *"roughly defined, but then it evolved based on what the team found out"* adding that it might be *"how it was supposed to work to some extent"*.

Development of the tool was perceived by the interviewees as an *"evolving"* process as well. Interviewee B said that the team *"didn't have a clue"* about the tool when the team started even though the team knew about general deliverables of a CII research team. Interviewee E also said *"I didn't feel like I knew up front what the final deliverables would look like and how we are going to get there"*. The second face-to-face meeting minutes noted that the team started discussing what kind of tool they would produce, and team considered developing two tools. The team continuously discussed tool development in the meetings, and in the seventh face-to-face meeting, which was about a year after the kickoff meeting, the team discussed the tool in-depth which was developed by the academics and pilot tested before this meeting according to the meeting minutes.

2.4 TEAM DYNAMICS

2.4.1 Team participation

Key comments from the interviewees in regard to team participation are listed in Table M6-6.

2.4.1.1 Participation and core group

As pointed out, one of the strengths the interviewees commonly perceived was that member participation was *"very good"*. Interviewees A and B recollected that level of participation *"stayed high"* except for one or two members who *"never participated"*. Interviewee B, the co-PI who had served on numerous CII research teams, thought that participation of this team was *"unusual"* compared to other teams on which he participated. The industry interviewees also thought that participant was *"very active"*. Interviewee C said that the associate Director of the CII Research Committee had told the team that the team participation had been *"extraordinary"*. Interviewee D recalled that the team *"didn't have a huge drop in attendance"* and that *"two-thirds of the original team size consistently attended meetings"*. Interviewee E mentioned about team participation as shown below.

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Academic – co-PI)	Interviewee C (Industry – owner co-chair)	Interviewee D (Industry)	Interviewee E (Industry)	Interviewee F (Industry)
Team Composition	• Program managers or functional managers or executives.	• Had good variety of project manager types.	• I think for the topic it was fine.	• VPs, division managers, functional managers. • Two suppliers.	• We had a number of VPs down to project manager.	
Team Diversity		• There wasn't certainly anything missing.		• We had a pretty diverse group. A lot of variation.	• I wouldn't say it was highly diverse.	
Team Attrition & Meeting Attendance	• Lost one or two members. • The rest stayed until at the end.	• The level of participation stayed high. • A couple of people never participated.	• CII told us it was extraordinary.	• 2/3 of the original team size consistently attended the meetings.	• It was very good.	• It was excellent considering circumstances. • The chairs did a good job.

Table M6-6: Team Participation – Interviews

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Academic – co-PI)	Interviewee C (Industry – owner co-chair)	Interviewee D (Industry)	Interviewee E (Industry)	Interviewee F (Industry)
Core Group		• Fairly distributed.	• I wouldn't say there was a core group.	• About 8 or 10 of us plus the academia group.	• Probably 12 including PIs and the GRA.	• Even participation.
Factors for Participation & Commitment	• Topic. • Nature of people.	• High level of interest. • Good personalities. • Meetings were productive. • Alignment. • Team make-up.	• Keeping people engaged between meetings. • Quality of the two PIs. • Topic was interesting.	• Interesting topic. • Well-facilitated. • Meetings were fun. • Learned something from ourselves. • Good group.	• Rotated (meeting) locations. • Had a really good team dynamics. • Assignment. • A lot of passion for the topic.	• Everybody spoke same language. • We rotated the meeting venues.
Subgroups	• ad-hoc.	• Broke up maybe in a meeting.	• I don't recall as formally.	• Ad-hoc sub-teams to look at specific issues.	• A lot of sub-teams working on different tasks.	• Not designed from the start. This approach evolved.

Table M6-6, continued.

> *"……probably 12 including PIs and the graduate research assistant, were there almost all the time, and very active. And, there were probably three others that were semi-active and then maybe a few very infrequently participate; they kind of check in from time to time,* [but] *didn't do whole lot."*

Interviewee F said that the team *"lost a couple of members including a member from South Africa"* and he thought that participation was *"excellent considering circumstances"*, and he added *"The chairs did a good job."* The loss of the member from South Africa was also mentioned by Interviewee E. This interviewee said that it was *"a challenge to be able to get the global participation"*. Interviewee E specifically recalled that the member in South Africa *"was really interested in continuing participation"*, so the team *"gave him work to do individually"*.

The average number of industry meeting attendees was 11 out of the total 16 industry team members with 68% of average attendance based on the available 6 face-to-face meeting minutes. From the analysis of the meeting rosters, 11 members attended more than three face-to-face meetings, and 7 members attended more than four face-to-face meetings including call-in participants. Two members never participated in any of the team meetings. Other two members attended only one meeting, and one of these was from Brazil. The number of attendees of each meeting did not fluctuated much, showing a standard deviation of 1.03.

When the interviewees were asked if there was a core group of people in the team, some interviewees answered that there was no core group, and a couple of interviewees said that about 12 people including the academics were a core group. Interviewee B and F described involvement of the team as *"fairly distributed"* and *"even participation"*. Interviewee C said *"I wouldn't say there was a core group."* Interviewees D and E responded differently. They thought that the team had *"a core team"* of about 12 people including the academics. Interviewee D commented that once the team *"got to a smaller core team"*, it felt like the team *"really made a lot of progress"*, and this core team *"ended up driving"* the team *"to a solution."*

2.4.1.2 Factors for team participation and commitment

The research topic and team dynamics were commonly referred as key factors for the high level of team participation and commitment of this team. Interviewee A regarded the topic and "the nature of people" as factors for participation adding that *"personal traits"* of people, such as, *"more outgoing, provoking, joking, and not being confrontational played a big role."* Interviewee B *"attributed it to the topic"* because *"both owners and contractors had a high level of interests"* in the topic. He also mentioned that they had good *"personalities of people on the team"*, trying *"to stay*

together and work on the topics". He added *"productive meetings", "good job of giving alignment"* and *"great make-up"* of the team as other factors.

Interviewee C said that he believed *"the primary reason"* was *"keeping people engaged between meetings and meetings that people couldn't attend"*. In addition, he also mentioned the *"quality of the two PIs"* and the topic that was *"interesting"*. Interviewee D listed interesting topic, good facilitation, fun meetings, and learning as the key factors that enabled the team *"to keep the two-thirds of participation"* from his perspective as quoted below.

> *"I think we all had common interests. The team enjoyed being together. …..The PIs did a good* [job of] *facilitation. They made it fun.* [The lead-PI' style] *was very informal style. He made the meetings fun. There was a lot of laughter. If we were just to meet once a month or two months and we had a very dry, planed and executed meeting, people wouldn't attend as much. But, the meetings were fun. We always learned something from the meetings. There was awful a lot of sharing."*

This interviewee added that the team was *"a good group"*, and *"keeping a team together is all about team dynamics."*

Interviewee E said that the team *"truly rotated locations"*, going to *"at least 7 or 8 locations to meet"*. Therefore, many of the team members *"were hosting one of the meetings"*, which *"was engaging"*. She also felt that the team *"had really good team dynamics"* where *"people just liked each other, and there was a lot of humor", "a lot of joking"*, and *"a lot of fun"*, so she thought that *"people enjoyed"* it. Another factor that she pointed out was that individual assignments were given to the members.

> *"……it seems to me we would assign certain things, in the meeting, we would say who's going to do what and so I would have an X,* [member A] *was going to do the top three lines,* [member B] *was going to do the next three, so, there wasn't an overlapping what the other people doing all the time. You had to do certain things. You didn't want to let the team down."*

This interviewee commented about the topic as well later in the interview as shown below.

> *"……when we started there was a lot of passion on the topic, a lot of the people, especially the guys in higher levels, vice president levels, the people doing the business and they were the ones affected, especially like contractors……"*

Interviewee F answered *"everybody spoke the same language because we were in the same project business and had common knowledge about it."* When this interviewee was asked what the chairs or PIs did to keep the team members continuously committed, his response was rotating meeting venues, *"which gave an opportunity to see different sites"*.

2.4.1.3 Subgroup approach

This team did not have a formalized subgroup approach. Instead, there were ad-hoc sub-team discussions in the meetings where the team broke up into smaller groups for the sub-teams to prepare the research deliverables and presentations for reporting out. Interviewee F said *"there were subgroups for efficiency focusing on "smaller pieces of work"*, and the team did *"subgroup discussions in the meetings as well"*. That *"was not designed from the start", and he said "this approach evolved."*

Interviewee D said that these *"ad-hoc sub-teams"* looked at *"specific issues, especially when it came time to present out"*. He noted that the team *"broke up into smaller groups during the meetings except for preparing the annual conference presentations."* The sub-teams preparing the annual conference *"met at the meetings and outside the meetings to work on the conference presentations."* Interviewee B also responded that the team used a sub-group approach *"close to the point"* when the team *"had the tool and had to write an implementation resource"*. Other than that, he did not remember whether the team had any formal sub-teams or not.

According to the meeting minutes, the team *"broke up into two groups"* to review and revise the definitions, which had been done as individual assignment of the members, in the third face-to-face meeting. The fifth face-to-face meeting was held in two different locations concurrently, and these two groups communicated through a conference call. These two groups had separate discussions and then communicated as a whole group. This particular meeting will be discussed further in section 2.4.3 Team communication later in this report. Since the meeting minutes of last 10 months of the research process are not available for the analysis, it is not known how the team formed sub-teams to prepare for the annual conference reporting out.

In regard to using a subgroup approach, several interviewees provided their opinions. Interviewee F recollected that *"subgroups were challenged by the rest of the team"*, and those *"interchanges and challenges were healthy"*. He then added that *"effectiveness depends on communications as a broader group"*. Interviewee C did not recall that the team had formal subgroups as his current team. He explained why his current team actively uses a subgroup approach as below.

> *"I will emphasize that the reason we do it on the current team, I am also a vice-chair on the current team, is because I drove that because*

of my learning from the first team. This's an example that training of the chairs would be helpful. I think [the use of] *sub-committee is the only way to go. There is no way to get 20 people to work* [together efficiently]*. I am sure that in our meetings, we broke into smaller meetings. On our current team, we have three subcommittees with different tasks and they meet independently and we have a fairly effective means I believe of reporting out so that subcommittees know what the other teams are doing. I think it is efficient, it is effective, and it has all sort positive attributes."*

Interviewee D recalled that the team used the sub-group approach where two groups met concurrently in two different locations in the fifth face-to-face meeting *"to maximize participation of everyone"*.

"……we met down to only, 9 or 10 that could meet in person, [but] *we still need input of all the others, and we didn't want them to be excluded. So, doing those sub-team breakouts was one way, and we had to design it into our meetings so we would meet, uh, come up with things needed to be done, and then we would think ahead, okay, the next meeting we know this people can't come but they are in the same area so they can get together and handle that task."*

2.4.2 Leadership

Key comments from interviewees and Post RT Survey respondents regarding leadership are listed in Table 6-7 and 6-8, respectively. Concerning the leadership of this team, Interviewee B perceived it as *"equal participation"* and *"equal effort on both the academic side and the industry side"*, whereas Interviewee C viewed it as *"60:40 academic-led"*, which he thought *"was not a problem"*. The third perspective on leadership came from Interviewee E. This interviewee discussed about leadership for subgroup discussion. Her perception was that the team *"had a lot of leaders"* and *"the leadership shifted"* depending on issues.

"In our group, there were always co-chairs, um, and it was very dynamic. As far as who was in the lead between the co-chairs, the academics, either PI, or someone else in the group, the leadership shifted all the time depending on what we were talking about and who had the expertise in that given area. There was always, there had to be someone doing the process checks, and, you know, we have to get this task done in this amount of time, but there was a lot of leadership guiding the group in different directions."

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Academic – co-PI)	Interviewee C (Industry – owner co-chair)	Interviewee D (Industry)	Interviewee E (Industry)	Interviewee F (Industry)
Leadership Orientation	• Strong leadership. • Complementary	• Equal participation.	• Academic-led. (60:40)		• Leadership shifted all the time.	
Co-chairs	• Their personalities were different. • Did not really separate roles and responsibilities.	• Owner co-chair kept us focused, kept the project moving. • Contractor co-chair was less administrative [management] style.	• Different styles. • Working relationship was very good.	• Owner co-chair had stronger beliefs. • Contractor chair had a broader perspective. • They worked well with the PIs.	• Owner co-chair: task master. • Contractor co-chair: more on the big picture. • Good leaders. • They shared responsibility.	• Owner co-chair was a good listener. • Contractor co-chair was fun and upfront. • Strong decision makers. • Complementary
PIs	• I did most of facilitating. • [The other PI] kept everybody focused.		• Lead-PI was eager and articulate. • Co-PI held himself back and restrained himself.		• PIs owned the calendar, and always had agenda prepared.	• Lead-PI was very structured. • Co-PI had industry background and experience. That really helped.

Table M6-7: Team Leadership – Interviews

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Academic – co-PI)	Interviewee C (Industry – owner co-chair)	Interviewee D (Industry)	Interviewee E (Industry)	Interviewee F (Industry)
PI & co-PI	• Close proximity. • Previous working experience.	• We had done some work together, so we had a great working relationship.		• Their styles were complementary.		
Leadership Communication	• We were always involved with chairs.	• Good communications with them.	• Leaderships meetings			
Leadership Roles & Responsibilities		• Co-chairs: made sure that meetings ran well. • PIs: carried the balls in terms of information.	• We pretty much worked as a group.		• The chairs did a lot of writing and editing. • They very much kept us on task.	• PIs: PIs drove the engagement of all members. • Co-chairs: led the meetings. They motivated people.

Table M6-7, continued.

Survey Question	Responses	Comments
The Principal Investigator(s) did a good job of structuring and facilitating this research.	• A total of 7 responses • 'Strongly Agree' – 3 • 'Agree' – 4	• Pretty good performance. My only suggestions here would be: (1) use the available tools (e.g., SharePoint) to share information and developments better with the entire team, and (2) work to keep the team informed more regularly about the work.
The Co-Chairs provided the expected leadership necessary for team success.	• A total of 7 responses • 'Strongly Agree' – 4 • 'Agree' – 3	• I'd say [the co-chairs] did a good job planning and guiding the team. There were a couple meetings that were not as effective when one or both of them couldn't attend, which highlights their performance and the importance of their companies fully supporting their participation.
The academic support (development of methodology, facilitation, data analyses, meeting support, etc.) was appropriate and met my expectations.	• A total of 7 responses • 'Strongly Agree' – 4 • 'Agree' – 3	• [The PIs and graduate student assistant] put in a lot of work on this.

Table M6-8: Team Leadership – Post RT survey

2.4.2.1 Industry Leadership

This team did not experience any leadership change for either the academic side or industry side. They had two co-chairs, each from the owner side and contractor side, and one lead-PI and one co-PI. The interviewees generally perceived that the two co-chairs were *"good leaders"* and *"complementary"* with each other with different styles and personalities.

In regard to styles and personalities of the two co-chairs, the owner co-chair was a *"project manager or task master"* who kept the team *"on track"* and *"focused and moving"*. He made sure that the team would *"meet every deliverables and every deadline"*, determined *"what's the next step"*, and what the team was *"going to do for the next meeting"*. He was a good listener, and he *"didn't mind discussing"* his *"stronger beliefs"*. The contractor co-chair was *"more on the big picture"* and *"more laid back in that sense of the deliverables"*. He was *"fun and upfront and engaging with the team"*, which an interviewee thought helped the team considerably. Interviewee B pointed out that the contractor co-chair was able to *"speak out from the contractor side and speak out their experience"*. The differences of the two co-chairs in personalities and styles were confirmed by the comment of Interviewee B as provided below.

> *"I* [speak] *out loud. If I have an idea, I just throw it out even if I haven't thought through it. Whereas the other chair's style is much more contemplative and thought-provoking, perhaps."*

Since the contractor co-chair was a *"less administrative guy"*, Interviewee B perceived the owner co-chair was *"the leader in managing of the team"*.

> *"You just had the right person keeping the team moving, which, as you know is, what you have to do for each project because once you start, the end is there, and it doesn't change, you just have to get there. Sometimes, you bog down a little bit, you get hung upon something. I think in this case* [the owner co-chair] *was real good at keeping us moving. We always talked to both of them* [the two co-chairs] *for meetings, agendas for meetings, so every meeting we had a good agenda to work from. …..When we* [the PIs] *needed help, he* [the owner co-chair] *was good at following up with the rest of team members. Because that's critical, these days, you tend to rely on your team members a lot, I think. If you have a chair who is good at sending out emails saying 'Hey guys we need get this and you need get this done, you need provide comments on this'. That's helpful. He did a good job of that."*

Both of the co-chairs were regarded as the good leaders by the interviewees. Interviewee E thought that *"both of them very much tried to recognize the strengths of the team members and utilize the strengths to the best advantage, and they were very good about letting others step up and advance certain areas of the team."* Interviewee F said that *"both chairs understood team dynamics, and they had good communication styles"*. He also described the co-chairs as *"strong decision makers"* with a *"good strategic perspective on the business"*.

2.4.2.2 Academic leadership

When asked about academic leadership of the team, the responses from the interviewees were related to the combination of the two PIs. The lead-PI was a junior faculty member at the time of the research, and the co-PI was a senior faculty member with rich CII research experience. They were in the same construction program at the same university. Interviewee C characterized the lead-PI as *"eager"*, *"articulate"*, and *"sometimes professor-like"*, which means the lead-PI was *"teaching and instructional"*. This interviewee described the co-PI as below.

> *"I could see him holding himself back, restraining himself and letting us struggle with the issues for the benefit of our discovery and our developing as a team instead of taking charge."*

He then added that although the younger professor was the lead without question, *"ironically,* [the co-PI] *really led the team from behind"*. He characterized the PIs in this way: *"an older person is wiser and can provide a right direction and a younger person might work harder"*. Interviewee D pointed out the benefit of having a PI with industry experience. He said the lead-PI was *"more casual"* and *"out-front"*.

> "[The co-PI] *was a senior academic brought 35 year of industry experience. He would validate ideas and ask probing questions that he experienced before in his career. He was not out-front. He was sitting with the group. He was like a senior advisor for the group……*[the lead-PI] *was much younger and had a more casual delivery style. He was more out-front. He asked probing questions that sometimes were off the wall…maybe thinking outside the box?"*

He commented that the two PIs *"styles were complementary"*. He also said that *"both PIs were very fun to be around"*, which he thought was *"very important"* since *"it could have been in a very rigid group"* otherwise. Interviewee E said that the co-PI's i and the co-PI brought "general CII knowhow" to the table, which the interviewee thought *"was very helpful"*. This interviewee pointed out that *"if it had just been only the junior researcher or two, it may have been much more difficult for them to understand how they needed for the team to progress in order to stay on schedule"*.

This experience and background of the co-PI was mentioned by Interviewee F as well. This interviewee qualified the co-PI as *"insightful"*, and said that the co-PI's industry background and experience *"intimately related to what the industry members were talking"* about, which really helped the team in his opinion. This interviewee characterized the lead-PI as *"very structured"* with *"strength in statistics and data collection – the research side"*. This interviewee commented that the two PIs *"drove the*

engagement of all members" and *"stimulated thoughts, and helped the industry members think beyond myopic scope"*.

These perceptions of the industry interviewee were consistent with those of the two PIs. Interviewee B thought that his work experience in a contractor company and, therefore, having *"a contractor's perspective of what goes on the industry"* gave him *"somewhat of an advantage"*. He commented that the lead-PI had *"a really excellent personality style, and he talks really well with the industry folks"*, which he thought helped the lead-PI *"connect"* with and get *"credibility"* from the industry members.

The two academic interviewees provided their opinions about their relationship as PIs of the team. Interviewee A thought *"the close proximity, working by each other, was the key."* He said that two PIs *"working at the same university"* would be much easier than working at separate universities. He also emphasized that *"if two PIs did not have working experience or did not know* [each other] *very well, it could be challenging."* Interviewee B had a similar thought on previous working relationships between PIs. He said that the two PIs had *"a great working relationship"* because they had done some research work together before this team.

2.4.2.3 Leadership Roles and Responsibilities

Interviewee C said that the PIs took charge of the research side, such as *"development of the data collection requirements and methods, defining what the final product would be and the format, delivering the research report, and validation of the data collection by statistical analysis."* Interviewee E recalled that the co-chairs did *"a lot of writing and editing"* for the research Summary, *"they were very much keeping the team on tasks"* focusing on the schedule. Interviewee F recollected that the co-chairs *"led the meetings"*, *"motivated people's thinking and engaging people"*, and *"actively participated in discussions*." This interviewee also mentioned that *"the chairs called the team members and tried to the members thought process engaged and focused"* when *"there was lag of time in between meetings"*.

Interviewee D described the differences in the roles and responsibilities of the co-chairs and the PIs as quoted below.

> *"They* [the co-chairs] *were more execution side of work – 'We have to get this done by this time.' Whereas the PIs were more focused on following the research process, the co-chairs were focused on agenda, schedule, making certain milestones, and that type of thing. They were the pushers. Making the team moving forward - our PIs did a little of that also."*

This interviewee noted what the co-chairs did for more productive meetings as well.

> *"The co-chairs eliminated some of the unnecessary steps from their perspectives so that we didn't get bogged down into details. They would meet with the PIs and work the agendas for the meetings together so that the meetings would be productive."*

Interviewee B characterized it as *"equal participation"* from the co-chairs and the PIs. He added that he did not think *"there was any dominance one way or another"*. He thought that *"part of that was"* the recognition of contributions that each other would make.

> *"You know, just think about that a little bit. Part of that was, I think, recognition by the industry guys that, academics have a certain skill set that's required in dealing some of the research and the industry guys recognized that. And I, as an academic, understood* [that] *the industry folks have contributions to make in terms of information that's more relevant to specific industry practices approaches…so I think, you know, we recognize that, so that helped sort of make the equality of effort in meetings."*

In regard to communication between the co-chairs and the PIs, this team had leadership meetings in preparation for whole team meetings. They *"collectively prepared the meeting agendas"* for the next meeting. They met by phone or by web-conference *"between meetings maybe once or twice"*. Interviewee C recollected, in addition to these in between leadership meetings, that *"the leadership group stayed a while afterwards for an hour or so, and debriefed about how the meeting went and talked about team dynamics"* at the end of face-to-face meetings, as *"probably most teams do"*.

Interviewee C, the owner co-chair interviewee, was asked if there were any challenges as a co-chair with no previous CII research experience. His first response was *"understanding what research is and what to do"*, which took him several months.

> *"Understanding the backend of the CII research year process… it is a one year process or maybe 15 months. By December of the second year, you need to be finished because you need to be prepared for the conference. That took me months to understand. I was disappointed frankly with that being the case. Maybe I wasn't listening at the first meeting, but it wasn't communicated effectively. I didn't get it, understanding my role and the process."*

He also said that it *"took some effort"* to understand the concept of 'PI', and what co-chairs' role versus the PI's role are. Another challenge to him was *"understanding the CII Knowledge Structure"*.

The Post RT Survey responses of this team showed very positive in terms of the industry and PI leadership as well as the graduate students. None of the survey participants provided negative responses (i.e. 'Disagree' or 'Strongly Disagree').

2.4.3 Team communications

Key comments from the interviewees and the Post RT Survey respondents in regard to team communication are listed in Table M6-9 and M6-10, respectively.

2.4.3.1 Team relationship

When asked about conflicts, the interviewees commonly responded that there were some different opinions between owners and contractors, and the team had a couple of *"outspoken"* members. Interviewee C said that the team *"had conflicts in opinions between owners and contractors"* initially, but he said *"we solved through* [these] *communication by staying neutral and professional"*. This interviewee made a similar comment about *"rivalry"* between owners and contractors during the scoping phase of the research. He recollected that it *"would create a red flag in the relationship between owners and contractors"*, but *"it created the avenue for conversation and discussion"* instead. He emphasized that *"there were a lot of constructive conflicts but no destructive conflicts"* and *"the important thing is that people's opinions were well listened and respected"*.

Another conflict, that this team had, involved a couple of outspoken members with strong personalities. One member, mentioned by the interviewees, had *"predefined ideas"* and *"was not satisfied"* with the direction of the team. He and another member tried to *"dominate the team discussions."* Interviewee B recalled that it *"wasn't really a huge problem"* even though *"it might have cost extra time"*. Interviewee C, the owner co-chair, did not recall that the team *"confronted them directly."* He said that the team *"just tried to minimize the impact by bringing them into subcommittees"*.

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Academic – co-PI)	Interviewee C (Industry – owner co-chair)	Interviewee D (Industry)	Interviewee E (Industry)	Interviewee F (Industry)
Conflicts	• Owners and contractors - There were some perspective differences.	• There was one member with predefined ideas.	• Conflicts in opinions between owners and contractors. • A couple of more outspoken individuals. • No personal value conflicts.	• A lot of constructive conflicts. • A couple of people who were very outspoken and with very strong personality.	• We had one team member that wasn't satisfied.	
Alignment Process	• The co-chairs facilitated the decision making.	• Collective discussion about issues.			• Decision making was primarily by consensus.	
Communications	• Used email, web meetings.	• Used email, web-meetings.		• The team members were well informed.	• PIs could have done better. • In person, email, conf. call.	

Table M6-9: Team Communications – Interviews

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Academic – co-PI)	Interviewee C (Industry – owner co-chair)	Interviewee D (Industry)	Interviewee E (Industry)	Interviewee F (Industry)
Meetings Agendas	• We drafted agenda.	• Good meeting agendas.				
Social Activities		• Dinner	• Team dinners.	• Team dinners.		
GRA	• Had industry experience. • Committed. • GRA took meeting notes and distributed meeting notes.	• Really excellent.	• The GRA was effective and tenacious during follow up.	• Developed the tool. • Took meeting minutes. • Did most correspondence.	• Wonderful. • Displayed leadership. • A very strong member of the team.	

Table M6-9, continued.

Survey Question	Responses	Comments
The research team was properly aligned throughout the project.	• A total of 7 responses • 'Strongly Agree' – 3 • 'Agree' – 4	• Necessary challenging was done with right intentions of getting a good product. • For the most part, I'd agree. There were a few stops and starts as different people surfaced (or re-surfaced) conflicting ideas, but those were managed pretty well.
The research team got off to a good start.	• A total of 7 responses • 'Strongly Agree' – 2 • 'Agree' – 4 • 'Neutral' – 1	
The research project plan and schedule were communicated and agreed to before significant work began.	• A total of 7 responses • 'Strongly Agree' – 4 • 'Agree' – 3	
What was the research team meeting frequency (both face-to-face and by phone/web?)		• For the first year, it was roughly face-to-face every 6-8 weeks, with occasional calls in between. • The team met more frequently initially during the early definition phase. On average we met face to face every other month. Smaller sub-team meetings were conducted by phone as well. • Typically met every two months or so. One of the things that I appreciated about our team was that I was not able to travel to attend many of the meetings but they found a way to keep me involved by teleconferences and/or through supporting assignments.
The research team meeting frequency (phone, web, face-to-face) was appropriate and efficient.	• A total of 7 responses • 'Strongly Agree' – 2 • 'Agree' – 5	• I think it was just about right -- only suggestion would've been to improve the communication around what was happening between meetings.

Table M6-10: Team Communications – Post RT survey

2.4.3.2 Team Meeting

Based on the analysis of meeting minutes of this team, the team had 6 face-to-face meetings including the kickoff meeting during the first year. According to the Post RT Survey respondents (Table 2-8), the team met every 6~8 weeks and several conference call meetings in between. The team used email as the main communication tool besides face-to-face meetings and conference calls. Interviewee E felt that the team did not utilize web technology enough to promote more participation.

> *"……I was kind of frustrated by the fact in this case, I don't know why, but I'm sure that they had technology, but, they, academics seem to kind of oppose to using [web technology]. We would set up conference calls so people could participate, but, you know, it's better if they can see what's going on. We weren't very good about using that technology, which was a little frustration to me because I thought it was an enabler to help us have better participation."*

The meeting agenda was prepared by the PIs and was discussed in the leadership meeting. Interviewee A described the co-chairs as *"a liaison of a whole group of industry to"* the PIs, and, he said that, therefore, whatever the PIs *"needed to prepare to present to the team went through the chairs first"*. Interviewee B also said that the PIs *"always talked to both of them for meetings and agendas for meetings, so every meeting had a good agenda to work from"*.

The meeting minutes were taken by the graduate research assistant and shared with the team members. When asked if the PIs kept everybody posted on meeting notes and progress, Interviewee E commented that they could have done a better job.

> *"I think they could have done a better job than they did, to be honest. I think, sometimes, it was always very good in terms of note taking for the meetings, we would review the notes of what happened. I think what might have been missing was that we didn't have necessary updates on what the academics were doing behind the scenes, maybe as frequently as we would have liked."*

One of the Post RT Survey respondents noted the same issue. For the survey question, 'The Principal Investigator(s) did a good job of structuring and facilitating this research', this respondent commented as below.

> *"Pretty good performance. My only suggestions here would be: (1) use the available tools (e.g., SharePoint) to share information and developments better with the entire team, and (2) work to keep the team*

informed more regularly about the work they [PIs] *were doing on their own between team meetings."*

The same respondent also made a similar comment; *"to improve the communication around what was happening between meetings"*.

One unique approach in terms of this team's meetings was that they had a concurrent face-to-face meeting in two different locations. Since the team consisted of *"geographically two groups"* and there were *"travel issues"*, the team decided to have two face-to-face meetings in two different locations and had *"web-based meeting"* between the two groups. Interviewee E explained this meeting approach as below.

"……we were going to meet in [city X], *and we had a lot of people in* [city X], *that could meet, but there was a group that was in* [region Y]. *The* [region Y] *group might have been able to get together face-to-face so they would do that, and they would do some sort of sub-tasks and then they would conference with the* [city X] *group and they would report out their sub-group work."*

Interviewee B thought that *"it worked pretty well"* and *"attendance wasn't too bad."* He recollected that the team *"did that two or three times"*.

"……One guy couldn't travel at all and he was on the east coast, so that worked well for him because he could just go over to the [the co-chair's] *office because they worked not that far* [apart]. *That was an effective way, I think, to get around a problem of being able to travel at that particular time."*

Based on the analysis of the available meeting minutes, the team used this meeting approach in the fifth face-to-face meeting. Group X gathered in city X, and group Y gathered in city Y. These two groups separately worked on different issues, and the two groups were connected via phone or web and discussed what each group did as a whole group.

With regard to meeting operations, Interviewee C, the owner co-chair interviewee said that the team had *"very structured ground rules."* These ground rules were about the face-to-face meeting length, location, the use of a call-in period. The details of these rules provided by this interviewee are presented as below.

"The meetings would be a full day on the first day and a half day on the 2nd day. …… We had a specific call-in period. We arranged the agenda and work so that three or four people who couldn't attend the meeting, say, 4-hour block, everybody [who attended the meeting in person] *would be at the meeting. We had another four people* [who could

not attend the meeting in person] *on the phone. And we all agreed to break into subgroups, and the four people who couldn't attend the meeting* [in person], *they broke up into a telephone meeting with a specific task. At the end of the four hours, everybody came together, all the three groups – two groups at the actual meeting location and the third virtual group, all had to report out. So it forced people who couldn't attend the meeting* [in person] *to participate, engage, and deliver a product. Everybody thought it was a very effective process.* [Typically in other meetings], *people on the phone are not participating. We gave them* [members on the phone] *work and deliverables to work on* [so that they can actually participate]*."*

Several interviewees commented on rotating meeting locations. Interviewee E and F thought rotating meeting locations was a factor in encouraging participation and commitment. Interviewee C provided other details about the meeting organization when he was asked what social activities the team had.

> *"At all places, our host typically would have executives come in for five minutes or a half hour, and talked about how they valued CII and valued the topic we were working on. So, that showed the connection.…… at most of our meetings, the host did something special. For example, when we were at* [company M], *we toured their process controls, simulation, and instrumentation facilities. At* [company N], *we rode a shuttle bus and toured their hydrogen filling stations. We did several* [such activities], *and they were good."*

The graduate research assistant was referred as a strength of this team by the interviewees. Interviewee C perceived the student as *"outstanding, quite mature, quite diligent, and able to work with people at all levels (high and low, old and young)."* He recollected that the student was *"essential"* in data collection, and *"effective and tenacious at follow up"*. For instance, this interviewee said, *"we had homework.* [The student] *would follow up and say "Did you do your homework?""* Interviewee E recalled that the student was *"wonderful"* and provided *"leadership as well"*. This interviewee perceived the student as a *"very strong member of the team"* who functioned *"equally with everyone else"*. Interviewee F also described the student as a *"good and prompt coordinator and communicator"* who was *"very involved with the project"*.

2.5 PRODUCT DESIGN AND DEVELOPMENT

Some of key comments from the interviewees and the Post RT Survey responses in regard to research products are listed in Table M6-11 and M6-12, respectively.

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Academic – co-PI)	Interviewee C (Industry – owner co-chair)	Interviewee D (Industry)	Interviewee E (Industry)	Interviewee F (Industry)
Product Quality		• High.	• Simple and seemingly effective tool. • Easy-to use.	• Relevance: 8 on a scale 1 to 10. • Usability: 7~8 on a scale 1 to 10.	• Some people were very happy with the results. Some were less happy.	• Quality: Very high. • Relevance: High marks.
Tool	• This tool helps you facilitate the process better.	• We didn't have a clue at start.	• If it is implemented, it is valuable.		• It could be made better over time with more data.	
Key Considerations in Tool Development	• Compatible with what industry thinks. • Easy-to-use.	• Easy to use. • Relevant to the industry. • Satisfies academic rigor.	• Easy-to use and easy-to-make	• Applicability. • Easy-to-use. • Usability. • User-friendly.		

Table M6-11: Research Products – Interviews

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Academic – co-PI)	Interviewee C (Industry – owner co-chair)	Interviewee D (Industry)	Interviewee E (Industry)	Interviewee F (Industry)
Industry Member Involvement	• We (academics) drafted them. The industry members edited them and commented on them.	• They actually wrote the research Summary.	• The research summary was written by the academics.	• The draft was sent out to the members for review and approval.	• For the implementation resource, I think we wrote up some examples how the tool was used.	
Feedback on the Products	• Some feedback.	• Not directly.	• I have not.	• I don't know if the team has received any feedback.	• I don't think I have had anyone after the Annual Conference with our report out.	• I have used the tool with customers to better understand their needs and interests.

Table M6-11, continued.

Survey Question	Responses	Comments
The research project deliverables (Research Summary and Implementation Resource, if appropriate) were most suited to improve performance of CII member companies.	• A total of 7 responses • 'Strongly Agree' – 4 • 'Agree' – 3	• A good starting point for companies without this element of a project management system.
The topic and research conducted were consistent with what I initially expected.	• A total of 7 responses • 'Strongly Agree' – 1 • 'Agree' – 6	• The research was close to what I expected. Only reason I don't 'strongly agree' is that I thought there might be more data collection, surveys, background research into other related CII projects.

Table M6-12: Research Products – Post RT survey

This team delivered 3 products – one research Summary, one implementation resource, and one research report. The team submitted the drafts of research summary and implementation resource to the CII Product Review Board on schedule, and the final research summary and the implementation resource were published before the team reported out at the CII Annual Conference. The implementation resource was ranked among top 20 most downloaded products of the reporting out year. However, their download numbers were not highly ranked in the following year, positioning near the average download number of all the CII products in that year. The Annual Conference Survey ratings on the Preliminary Session and Implementation Session of this team were not highly ranked out of 8 research teams that reported out in that year.

All of the interviewees were satisfied with the quality of the products that the team produced. The interviewees perceived the quality of the tool that the team developed as *"high"* and *"effective"*. Interviewee B recollected that there was *"some skepticism at the beginning when the project wasn't well defined"*. However, the interviewee said that as the team *"started moving toward what the tool looked like"*, the industry members said *"yes, this works, provides good information"*. When asked about key considerations in developing the tool, the interviewees commonly picked *"easy-to-use"* and *"applicability"* or *"relevance"* to the industry.

There were conflicting comments regarding industry member participation in developing the research deliverables (i.e., research summary, implementation resource). Some interviewees responded that the academics drafted the research summary and the implementation resource and the industry members reviewed the drafts, whereas other interviewees said that the industry members participated in writing the research summary and the implementation resource. The principal authors named in the research summary and in the implementation resource were the two PIs, the graduate research assistant, and the two co-chairs. Interviewee C, the owner co-chair interviewee, said *"I am going to assume that the research summary was written by the academics. I am sure we all approved it. I don't recall."* Interviewee A recollected that *"the first drafts were done by the PIs"*, and *"the industry members edited and commented on them."* Interviewee D did not think that *"the sub-teams had to develop any specific documents."* Interviewee E said that the team *"wrote up some examples how the tool was used, and "sub-groups would go away and write up these different scenarios"* for the implementation resource even though the industry members did not write the whole thing.

> *"……we felt that in order for our peers and our companies to use tools that we need to have that* [industry] *input to those implementation resources in particular."*

Interviewee B recollected that the industry members actually wrote the research summary and some parts of the implementation resource when he was talking about the industry homework and involvement of this team.

> *"……I think they* [the two chairs] *actually wrote the Research Summary. Sometimes the Research Summary gets written by academics, and it's not supposed to. That have been my experience with the stuff I have done, but this group, they did write. The owner chair was good,* [was] *looking at what was supposed to be done, making sure whatever the committee* [team]*, the industry guys were supposed to do, he made sure they did it. When the time came to write the Research Summary, the co-chairs took the lead.* [They] *petty much did that. We provided input, we got to read and comment on that.* [For] *the Implementation Resource, we actually had a meeting where we divided the group up and they wrote parts of it right in the meeting. And so, we sort of aggregated what they wrote, and then, started passing it around for review. That was something new and different. I hadn't done that before. Usually,* [for] *the Implementation Resource, my past experience was* [that it was] *totally written by academics. So that was unique, I think, with this group from my experience."*

The minutes of the seventh face-to-face meeting, which was less than 10 months before report out, noted *"writing assignments"*. According to this *"writing assignments"*, the two co-chairs were to *"develop a sentence outline"* of the research summary and

"send it out to the team" for comments. Then, the co-chairs would *"write it based on the sentence outline and comments from the team"* and then would *"send out a draft to the team to review and revise"*. Finally, the co-chairs were to *"revise and write the final draft"* of the research Summary. The implementation resource was to be drafted by the graduate research assistant, and to be sent out to the team for review. These minutes also shows *"a preliminary schedule for development of the research Summary"* that was developed by the owner co-chair. However, since meeting minutes after this seventh meeting are not available for analysis, it is not clear how the industry team members were involved in development of the research summary and the implementation resource.

Appendix M7

Individual Case Description Report

Atypical Case: A1

Table of Contents

List of Tables

1. Introduction

1.1 CASE INFORMATION

Table M7-1 summarizes the overall information of the case A1.

Case Category	Atypical		
General	Project period	Total 3 years	one year extension
	Kickoff date	Late November	
Industry Chairs	Number of chairs	2 co-chairs	One owner co-chair retired
	Change in chairs	No	
	Previous CII experience	No	
Principal Investigators (PIs)	Number of PIs	2 PIs	
	Change in PIs	Yes	The lead PI was replaced by another academic
	Previous CII experience	Yes	
Team members	Number of members (excl. academics)	Kickoff meeting: 23	Owner: 11, Contractor: 12
		Reporting out: 10	Owner: 6, Contractor: 4
	Number of members with previous CII research team experience (excl. chairs)	2	
Research Methodology	Research Method	Survey	Quantitative
	Validation Process	No	
Products	Products published	Research Summary: 1	
		Implementation Resource: 0	
		Research Report: 1	

Table M7-1: Case Information

1.2 DATA SOURCES

The main data source for this case study was individual interviews with two members of this team. Other data sources to support and/or supplement the interviews included CII Post Research Team Survey (Post RT Survey) responses of this team and

CII documents and archival records. The detailed data sources and their availability for analysis are summarized in Table M7-2. All the available sources in Table M7-2 were analyzed to investigate the case from multiple perspectives. Words, phrases, and sentences in italic font with quotation marks in this case description indicate direct quotes from the interviews or comments of the Post RT Survey respondents.

Data Type	Data Source		Available and used for analysis
Interview	2 interviews	1 academics	Yes
		1 industry team member	Yes
Documentation	Team documents (retrieved from CII SharePoint)	Research Topic Statement	Yes
		Proposal	Yes
		Charter	Yes
		Meeting agenda	No
		Meeting minutes	2 meeting minutes
		Interim Reports	Yes (2 reports)
		Team roster	Yes
		Detailed research project schedule	No
	Research products	Research Summary	Yes
		Implementation Resource	No
		Research Report	Yes
Archival Records	CII surveys	CII Post Research Team Survey	Yes
		Annual Conference Evaluation Survey	Yes
	CII records	CII product usage - Hardcopy sales and e-copy downloads numbers	Yes
		CII team meeting attendance record	No

Table M7-2: Data Sources

1.2.1 Interviews

For this team, 2 members were interviewed. One was the PI who replaced the original lead-PI in the second year, and the other interviewee was an industry team member. Both interviews were conducted individually at a different time and place. The interview dialogues were digitally voice-recorded upon the consent of the interviewees.

1.2.2 CII Post Research Team Survey (Post RT Survey)

Only 3 team members responded the CII Post RT Survey. The Post RT Survey is sent by CII to every CII research team member after the team reported out at a CII Annual Conference. The survey analysis considered the ratings and comments that the respondents provided in a narrative form. Since only a small number of the team members responded, any statistics on the respondents' ratings based on a five-point scale were only regarded as referential.

1.2.3 Other Data Sources

Other data sources collected and reviewed for this case were team documents and CII archival records relevant to this case. The team documents included the research topic statement provided to this team by CII, the proposal submitted by the PIs to CII, the team charter, meeting minutes, team rosters, interim reports submitted to CII by the team, and the research products that the team delivered (i.e., research summary and research report). The CII archival records included CII Post RT Survey responses, CII Annual Conference Evaluation Survey ratings, and hardcopy sales and e-copy downloads numbers of the research products of this team.

2. Case Analysis

2.1 CASE OVERVIEW

This team started as a 2-year research team with a kickoff meeting in late November. The target report-out date was in 20 months from the kickoff meeting. The team had 1-year extension after the dress rehearsal for the conference presentation. The team had 2 co-chairs from owner and contractor each. The owner co-chairs dropped out the team midway through the process due to retirement. The replacement was not made, and the remaining co-chair was solely in charge of industry leadership.

The team involved with two academics. Both Principal Investigators (PIs) had previous CII research experience and held an engineering background specializing in construction management. The lead-PI moved to a different institution in the beginning of the second year, and he was replaced another academic from his original institution. The replacing PI did not have any prior CII research experience.

According to the kickoff meeting roster, the team had a total of 23 members excluding 2 academics. Of the 23 members, 11 members were from owner companies and 12 were from contractor companies. Of the 23 members, 15 were managers, and 4 were in a director position, and 10 members were managers or specialists specifically

related to the topic, and the others worked in construction or project management disciplines. The team members listed in the research summary were a total of 10 with 6 owner members and 4 contractor members. Of 23 initial team members, only 2 members had been on CII research teams prior to this team. This team was the first CII research team for both co-chairs.

2.2 STRENGTHS AND WEAKNESSES

Table M7-3 includes key responses of the interviewees to about strengths and weaknesses and/or challenges of this team.

Question Category	Academic Interviewee	Industry Interviewee
Strengths		• Good leadership from industry • By the end it probably six people do the all the work.
Weaknesses / Challenges	• The two PIs were not getting along. They had different management styles. • When I was brought in, the team participation was deteriorated. They lost involvement. • …the fundamental research methodology….was somewhat flawed. • There was a problem with the industry chair.	• Disappointed with the results • [The original two PIs] did not mix well together at all. • [The lead-PI] eventually moved on to [different university], which was a problem. • [The team] got a late start.

Table M7-3: Strengths and Weaknesses – Interviews

The major weakness mentioned by both interviewees was the performance of the lead-PI – the lead-PI left the team in the middle of the process without appropriate handover. In addition to this, the academic interviewee thought that the research methodology was a weakness, and the industry interviewee also made similar comments. One notable point was that there were conflicting views from the two interviewees on the industry leadership by the contractor co-chair. The academic interviewee considered industry leadership as a weakness while the industry interviewee stressed it as a strength.

In fact, during the interview, the industry interviewee continuously emphasized the strong leadership of the industry co-chair.

The academic interviewee recalled that the original two PIs had *"different management styles"*, and they did not seem to have a strong relationship. Another weakness mentioned by this interviewee was deterioration of team participation.

> *"The major weakness was specific involvement of team members. What happened during the six months just before I joined was, I think, they* [the team members] *lost interests. They lost involvement. These things go together. If you are not involved, it is very easy to lose interests."*

While the academic interviewee recollected that *"there was a problem with the industry chair",* the industry interviewee perceived the other way.

> *"We had a good leadership from industry.* [The co-chair] *was a good leader and a number of other people on the project particularly the ones from industry that I thought were very good. They were generous about their time, effort, and thoughts."*

The industry interviewee mentioned about the late start, which was a weakness, and he thought that the team motivation was degraded since the team had some interface issues with CII in regard to one-year extension of research.

> *"We got a late start by several months, and it became obvious to us we were not going to a good project in order to report out at the end of that second year."*

2.3 RESEARCH METHODOLOGY

Key comments from the interviewees and the Post RT Survey respondents in regard to research methodology are listed Table M7-4 and Table M7-5, respectively.

The team seemed to have a good start with active member participation, as the industry interviewee and one of the Post RT Survey respondents commented. The industry interviewee thought that they *"were productive in early days"* and *"12 members out of 20 members showed up in the meetings"*. The meeting notes of the second and third face-to-face meetings support this indicating 14 and 12 attendees, respectively.

Question Category	Academic Interviewee	Industry Interviewee
Research Topic	• The topic was fine, a great topic.	
Alignment around the Scope		• We kept reminding ourselves where we were heading to and what we were trying to do.
Scoping Phase		• We were productive in early days.
Research Methodology	• I would have approached differently.	• Survey responses - narrow distributions
Data Collection		• Long lag in getting data. • Some data were lost. • We ended up with much fewer projects.

Table M7-4: Research Methodology – Interviews

Survey Question	Responses	Comments
The team had an appropriate and well organized data collection plan	• A total of 3 responses • 'Strongly Agree' – 1 • 'Disagree' – 2	• Some of our surveys were lost when they went to [the lead-PI's institution]. The [graduate student] had a difficulty in reporting when they received the survey information
The quality of data collected and overall research met my expectations.	• A total of 3 responses • 'Agree' – 2 • 'Disagree' – 1	
The data collection plan was well executed.	• A total of 3 responses • 'Disagree' – 3	• I have no idea what happened to the data. • Plan not strongly executed due to PI issues. Grad student used on project didn't seem reliable, but may have just been a reflection of issues with team communication with PI.

Table M7-5: Research Methodology – Post RT Survey Responses

The apparent problem in data collection was mishandling of data according to the Post RT Survey in Table 2-3. The industry interviewee also thought that the fact that some of data were missing influenced the team morale.

> "[The lead-PI] *left in the middle of the research process. It would be much better to say 'Hey, I am moving on. Done. You guys need somebody else.' But, kind of trying to stay on and not being able to manage the graduate student down collecting data…That really hurt the team."*

Secondly, the industry interviewee recalled a *"shortage of the projects was a challenge"* and the team had a trouble in *"getting a sufficient amount of data in a timely way"*. One respondent of the Post RT Survey considered the economic situation at that time as a factor of this lack of data with a comment *"Strong intent at the beginning that was impacted by economic downturn that cancelled or delayed many projects we were counting on."* According to the research report of this team, the number of projects surveyed was 31 and the survey responses received from these 31 projects were more than 1,000.

The real problem in data collection might not have been the numbers of projects or survey responses that the team collected. The academic interviewee noted that the methodology developed by the original two PIs was *"somewhat flawed"* in getting right data to answer the research questions. The main data collection method of this research team was a survey approach which intended to gather responses from construction personnel of identified case projects. Both academic and industry interviewees mentioned that the data tended to have a narrower variability mainly due to the fact that all of the projects selected for survey data collection were CII member companies that were in general relatively higher performance organizations in the industry.

> *"…the fundamental research methodology……was somewhat flawed. The project was to compare good and poor* [performers in regard to the topic]*..... The problem was that the methodology only included CII member companies. CII member companies are top performers compared to non-CII companies. They had no poor performers in their methodology."* – Academic Interviewee

> *"One problem with the survey was that the projects had all good* [topic] *performance since they were from CII member companies. So it was narrow distributions."* – Industry Interviewee

2.4 TEAM DYNAMICS

Key comments from the interviewees and the Post RT Survey respondents in regard to team dynamics are listed Table M7-6 and Table M7-7, respectively.

Question Category	Academic Interviewee	Industry Interviewee
Team Composition		• Very good mix of experienced people. • More senior type people. • Mostly construction project management people who understood [the topic].
Core Group	• Four including the two PIs.	• Six people
Participation & Commitment	• Very few team members left when I joined. • [The members] lost interest and involvement.	
Factors for Participation & Commitment		• The [contractor] co-chair. He did a good job keeping the team together.
Subgroups		• Not really
Chairs	• A lot of performance issues and involvement issues	• A very good leader. Very objective. Took large roles and responsibilities. • The vice-chair [owner co-chair] retired. He didn't do very much.
PIs	• There was no handover.	• [The two PIs] did not mix together well. • [The two PIs] focus wasn't there. • [The co-PIs] was ineffective.
GRA	• Had no quantitative or statistical skills.	
Team Operation & Management		• No contentious atmosphere. • There was disagreement but in a professional way. • [The contractor co-chair] ran a good meeting.

Table M7-6: Team Dynamics – Interviews

Survey Question	Responses	Comments
The Principal Investigator(s) (team academic(s)) did a good job of structuring and facilitating this research.	• A total of 3 responses • 'Disagree'– 2 • 'Strongly Disagree' – 1	• Our PI's failed miserably....and we had unexpected delays and failed to present (in 2009) within the allotted time frame. • Our initial PI changed universities during our project.
The Co-Chairs provided the expected leadership necessary for team success.	• A total of 3 responses • 'Strongly Agree' – 2 • 'Disagree' – 1	• [The owner co-chair] retired and [the contractor co-chair] stepped forward in a very strong way to lead the team.
The academic support (development of methodology, facilitation, data analyses, meeting support, etc.) was appropriate and met my expectations.	• A total of 3 responses • 'Neutral' – 1 • 'Disagree' – 2	• Again, PI dismissal and transition was a great negative impact to our team.
The research team was properly aligned throughout the project.	• A total of 3 responses • 'Neutral' – 2 • 'Disagree' – 1	• Clear direction and feedback were very sporadic. I offered 8 to 10 of my projects for the surveys. Started strong, lost focus with PI dismissal, [and] got somewhat refocused to finish our work.
The research team got off to a good start.	• A total of 3 responses • 'Strongly Agree' – 2 • 'Disagree' – 1	
The research project plan and schedule were communicated and agreed to before significant work began.	• A total of 3 responses • 'Agree' – 2 • 'Neutral' – 1	• The first few meetings and calls I attended were about establishing a plan and schedule. I don't know if we ever met the plan elements or schedule.
What was the research team meeting frequency (both face-to-face and by phone/web?)		• At first it seemed to be adequate, but when the team failed to answer email and calls, I lost all contact. • Initially monthly, then less frequent when PI problems surfaced, then monthly to finish work.
The research team meeting frequency (phone, web, face-to-face) was appropriate and efficient.	• A total of 3 responses • 'Agree' – 1 • 'Neutral' – 2	

Table M7-7: Team Dynamics – Post RT Survey Responses

2.4.1 Team Composition

The industry interviewee said that the team had *"very good mix of experienced people from owners and contractors"* and team members were *"more senior type"* of people having *"20 or 25 years of experience"*. He also noted that the topic was *"not for five or six year experience people"* and *"many of them* [the industry members] *were construction project management people who understood* [the topic]*"*. The team roster noted that most members worked as construction managers or specialists in disciplines specifically related to the topic. Therefore, it can be concluded that the team had sufficient expertise and experience focused on the topic before starting losing members. Another aspect with regard to the team composition is that the two co-chairs, including one who dropped out, did not have prior CII research experience. On the contrary, the original two PIs had served as PIs on a previous CII research team.

2.4.2 Team participation and commitment

As the industry interviewee and one respondent of the CII Post RT Survey commented, the team had a good start. However, the team attrition was significant. The academic interviewee said that the *"team had a very few team members left"* when he joined *"nearly in the second year"*. The team roster at the kickoff meeting shows 23 industry members whereas the research summary listed only 10 industry members, which means that the team lost more than half of the industry team members.

The academic interviewee also recollected that there was good participation and excitement from the industry members about six months before he joined the team.

> *"Since I knew both PIs, they invited me to come by. It was six months earlier and there were a lot of team members and a lot of excitement. However, when I was brought in, the team participation was deteriorated."*

This interviewee also said *"what happened was there was a lot of blame for the lead- PI* [the PI who left]*"*. His perception was that the team members *"lost interest"* and *"lost involvement"* during that 6-month period. As a result, a core group of only about 5 members left including the 2 PIs and the co-chair according to the interviewees. Another supporting evidence of low participation of the team members was the number of the members participating when the team reported out. Based on the CII Annual Conference Attendance Report, only 5 industry members including the co-chair attended the Annual Conference where the team presented their research results.

2.4.2.1 Industry leadership

There were contradictory views of industry leadership across interviews and the Post RT Survey responses. The owner co-chair did not actively participate in the team meetings, and eventually withdrew from the research as stated in the third interim report submitted to CII. As a result, the contractor co-chair took the sole responsibility of industry leadership. The industry interviewee strongly characterized this co-chair as a *"good leader" and "professional"*, and he was the one who kept the team together. This interviewee perceived that the contractor co-chair as a key factor for completing the research.

> "*If* [the contractor co-chair] *didn't have enthusiasm and personal commitment to this project, if it was not for that, this project really would have been a disaster. If a final product is worth of anything, in my mind,* [the remaining co-chair] *is the one who made that happen, because he overcame the adversities of* [the lead-PI] *and some of ineffectiveness of [the co-PI] in that the middle period."*

The academic interviewee, on the contrary, thought that there was a *"problem with the industry chair"*.

> *"I recall that a lot of performance issues and involvement issues, keeping the team together, a lot of that responsibility were perceived to be the chair's responsibility."*

This contradiction also appeared in the Post RT Survey responses. One respondent commented as below to the question 'The Co-Chairs provided the expected leadership necessary for team success.'

> "…. [the contractor co-chair] *stepped forward in a very strong way to lead the team. Primarily through his leadership, our team stayed together for a 2nd year and successfully completed our research and presentation at the CII conference."*

Another respondent commented oppositely to other question asking about time commitment to the research.

> "*I was committed to whatever was needed. I called* [the contractor co-chair' name] *on several occasions to see what I could do to help. I offered to help with the Power Point presentations but received no call back."*

The contractor co-chair seemed to have 'strong' leadership and play a critical role in completing the research withstanding the problems associated with the lead-PI. In spite,

it is likely that the co-chair did not effectively manage and operate the team particularly from the communication perspective.

2.4.2.2 Academic leadership

The main problem of this team was the performance of the lead-PI. The lead-PI moved to other institution in the "*middle of the research process*". The industry interviewee said "… [The PI's] *focus wasn't there…*" The CII Post RT Survey respondents were not satisfied as well.

One of the major consequences was mishandling of the survey data collected from the case projects as described in the previous section. The lead-PI did not seem to communicate well with the team in regard to the survey procedure. One respondent of the CII Post RT Survey addressed this issue as presented below.

> "*Clear direction and feedback were very sporadic. I offered 8 to 10 of my projects for the surveys. There were issues with getting the surveys to me to send to the projects. There were also issues on returning the surveys back to the University. I did not receive the second set of surveys that were a follow up to the first survey. I never received any feedback on how the data fit into the project.*"

Another issue was the relationship between the two original PIs. Both interviewees recollected that the two PIs "*did not mix together well*" and "*could not work together*". When the lead-PI was dismissed by CII, the co-PI became in charge of a primary role in leading the research side, and the substitute PI supported him. According to the academic interviewee, he chose to "*facilitate and assist*" rather than to "*step up as a lead-PI*". In short, the co-PI took over the lead-PI role, and the academic interviewee played a co-PI role.

The graduate student working for this project also seemed to have a problem with regard to data collection and analysis. The academic interviewee said that the graduate student "*was not qualified to do statistical analyses on survey data collected*" and did not have "*engineering or statistical background*". The industry interviewee recollected that the graduate student attended "*a couple of meeting, not every meeting*". One respondent of the Post RT Survey commented that "g*rad student used on project didn't seem reliable, but may have just been a reflection of issues with team communication with PI*", which also implies that there was also a communication issue between the team and the lead-PI.

2.5 PRODUCT DESIGN AND DEVELOPMENT

Key comments from the interviewees and the Post RT Survey responses in regard to product quality are listed Table M7-8 and Table M7-9, respectively.

Question Category	Academic Interviewee	Industry Interviewee
Product Quality	• I feel pretty good. • We were able to marry research results with a tool.	• No better than the average.

Table M7-8: Product Quality – Interviews

Survey Question	Responses	Comments
The research project deliverables (Research Summary and Implementation Resource, if appropriate) were most suited to improve performance of CII member companies.	• A total of 3 responses • 'Strongly Agree' – 1 • 'Agree' – 2	• I have no idea what the research summary contained. I was not copied or include in any of the findings or on any presentation information.
The topic and research conducted were consistent with what I initially expected.	• A total of 3 responses • 'Strongly Agree' – 1 • 'Agree' – 1 • 'Strongly Disagree' – 1	• The topic seemed to be appropriate and within my area of interest and expertise. Because I was not in the initial meeting, I received very little background on CII or the project.

Table M7-9: Product Quality – Post RT Survey Responses

Table 2-6 shows the perceptions of the two interviews to the quality of the products that the team produced. The academic interviewee seemed satisfied to a certain degree with the deliverables that the team produced saying that he felt *"pretty good about the final products, reports, tools and presentations"*, and the team was *"able to marry research results with a tool"*. However, this team did not product an implementation resource as guidance for implementation of the research results. On the contrary, the industry interviewee assessed the deliverables as *"no better than the average based on data we* [the team] *had and conclusions we* [the team] *draw."*

The combined rating of this team on the plenary session and the implementation session from the CII Annual Conference Survey was in lower rankings among the 8 teams that reported out at the same conference. However, the product download numbers

of this team appeared to be strong. The download popularity of the research summary of this team was on the top 10 list of the year that it was published among nearly 500 CII products available for download. Another notable point is that the hard-copy sales of this product at that year was more than 90, which is unusual considering the fact that hard-copy sales have been continuously decreasing since CII products become available in year of 2001. For example, the hard-copy sales number of the top downloaded product of that year was only 4.

It would be too early to evaluate the product quality based on the download and sales numbers of this team since its products have not been available to the CII members long enough to fully assess its implementability and value. However, it is possible to draw a couple of potential explanations of the relatively high popularity of this team's products. First, the research topic area of this team is of industry interest so that the industry wants to look at them first. Second, the products that the team produced actually contain valuable information for the industry. It will be the future step to assess the level of usage and implementation of the products by the CII member companies for a five or ten year-period to better evaluate the value of the products and to identify real drivers of its download popularity.

Appendix M8

Individual Case Description Report

Atypical Case: A2

Table of Contents

List of Tables

1. Introduction

1.1 CASE INFORMATION

Table M8-1 summarizes the overall information of the case A2.

Case Category	Atypical		
Project	Project period	Total 2 years	
	kickoff date	Late October	
Industry Chairs	Number of chairs	2 co-chairs	
	Change in chairs	No	
	Previous CII experience	Yes (owner co-chair) No (contractor co-chair)	
Principal Investigators (PIs)	Number of PIs	2 PIs	
	Change in PIs	No	
	Previous CII experience	No (lead-PI) Yes (co-PI)	
Team members	Number of members (excl. academics)	Kickoff: 16	Owner: 10, Contractor: 6
		Report out: 16	Owner: 7, Contractor: 9
	Number of industry members with previous CII research team experience (excl. chairs)	3	3 – one team 1 – two teams
Research Methodology	Research Method	Interview	
	Validation Process		
Products	Products published	Research Summary: 0	
		Implementation Resource: 0	
		Research Report: 1	

Table M8-1: Case Information

1.2 DATA SOURCES

The main data source for this case study was individual interviews with 4 members of this team. Other data sources to support and/or supplement the interviews included CII Post Research Team Survey (Post RT Survey) responses of this team and CII documents and archival records. The detailed data sources and their availability for analysis are summarized in Table M8-2. All the available sources in Table M8-2 were analyzed to investigate the case from multiple perspectives. Words, phrases, and sentences in italic font with quotation marks in this case description indicate direct quotes from the interviews or comments of the Post RT Survey respondents.

Data Type	Data Source		Available and used for analysis
Interview	4 interviews	1 academics	Yes
		3 industry team members	Yes
Documentation	Team documents (retrieved from CII SharePoint)	Research Topic Statement	Yes
		Proposal	Yes
		Charter	Yes
		Meeting agenda	No
		Meeting minutes	1 conference-call meeting minutes
		Interim Reports	Yes (2 reports)
		Team roster	Yes
		Detailed research project schedule	Yes
	Research products	Research Summary	Yes (draft)
		Implementation Resource	No
		Research Report	Yes
Archival Records	CII surveys	CII Post Research Team Survey	Yes
		Annual Conference Evaluation Survey	Yes
	CII records	CII product usage - Hardcopy sales and e-copy downloads numbers	No
		CII team meeting attendance record	Yes (only last 6 months)

Table M8-2: Data Sources

1.2.1 Interviews

For this team, 1 academic and 3 industry members were interviewed. One of the 3 industry team member interviewees was the contractor co-chair, and only one industry interviewee had previous CII research team experience. Each interview was conducted on a one-to-one basis at a different time and place. Interview durations ranged from 1.5 to 2.5 hours with an average of 1.9 hours depending on interviewees' time availability. Dialogues of all the interviews were digitally voice-recorded upon the written consent of the interviewees.

1.2.2 CII Post Research Team Survey (Post RT Survey)

A total of 4 industry team members responded the CII Post RT Survey. The Post RT Survey is sent by CII to every CII research team member after the team reported out at a CII Annual Conference. The survey analysis considered the ratings and comments that the respondents provided in a narrative form. Since only a small number of the team members responded, any statistics on the respondents' ratings based on a five-point scale were only regarded as referential.

1.2.3 Other data sources

Other data sources collected and reviewed for this case were team documents and CII archival records relevant to this case. The team documents included the research topic statement provided to this team by CII, the proposal submitted by the PIs to CII, the team charter, meeting minutes, team rosters, interim reports submitted to CII by the team, and the research products that the team delivered (i.e., research report). The CII archival records included CII Post RT Survey responses, CII Annual Conference Evaluation Survey ratings, and hardcopy sales and e-copy downloads numbers of the research products of this team.

2. Case Analysis

2.1 CASE OVERVIEW

The team started with a kickoff meeting in late October with a target report out date in approximately 21 months. The research topic statement was provided to the team with the essential question and potential deliverables. According to the interim report, which was submitted to CII in its fifth month, the team charter was finalized three months after the kickoff meeting.

This team did not experience any leadership changes. The two co-chairs and the two PIs stayed until the end of the research. The owner co-chair of this team had participated on a prior CII research team, and the contractor co-chair had no prior CII research experience. The lead-PI did not have previous CII research team experience either, whereas the co-PI had served on two CII research teams as a PI. The lead-PI specialized in an engineering discipline other than civil engineering. However, the co-PI had civil engineering background specializing in construction management. Both PIs were from the same institution.

The initial members of this team were 16 industry members, 2 PIs and 1 graduate research assistant according to the team roster as of the kickoff meeting. Of 16 industry members, 10 were from owner companies, and 6 were from contractor companies. When the team reported out, 16 industry members were listed on the team roster; 7 members were from the owner side and 9 members were from the contractor side.

2.2 STRENGTHS AND WEAKNESSES

Table M8-3 includes key responses of the four interviewees about strengths, weaknesses and/or challenges, and unique aspects of this team.

The interviewees commonly regarded the team composition as one of strengths of this team. Interviewee B, the contractor co-chair, thought that *"the diversity of the team"* was a strength because there were some members from other industries than construction industry. Similarly, Interviewee C said that the team members *"were knowledgeable about the subject"* both in construction and the topic area. Interviewee A, the lead-PI interviewee, perceived the structure of the team, which means the team comprised of academics and industry people, as a main strength of this team as below:

> *"The main strength is the structure of the team. The fact that industry people work with academics provides all the positive sides. Very realistic focus of the research."*

However, this interviewee also offered a negative aspect to the team composition as below.

> *"The negatives side of this is that nobody has ever done what I consider research. If you define research as identifying good practices, then this structure will work really well. They are all experts. They were really willing to share things that they thought worked well for their companies and would work for other companies. But not every practice works for every project."*

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Industry – contractor co-chair)	Interviewee C (Industry member)	Interviewee D (Industry member)
Strengths	• The structure of the team - industry people work with academics. • They are all experts. • Team dynamics was really good.	• Diversity of the team.	• People who were knowledgeable about the subject.	• The team dynamics was good.
Weaknesses / Challenges	• The problem was what they [members] provided was what worked today [current practices]. • Two opinionated members. • I didn't understand the CII process.	• The economic situation went bad. • We didn't use web meeting technology very much.	• When the team started, the economic was not good. – travel restrictions.	• That was during the recession, we lost team members.
Unique / Innovative Approaches		• We interviewed field people. • We interviewed people with a prototype tool asking about the use of the tool.		• The overall theme [research topic] was unique. • Our tool was towards more workers in the field.

Table M8-3: Strengths and Weaknesses – Interviews

This interviewee also pointed out that *"the problem was what they provided was what worked today"*, which meant the current practices, even though *"the team dynamics was good"* and *"people provided really good input"*. One challenge that this interviewee mentioned was a struggle with a couple of members who tried to lead the research direction in the direction that they thought it should be. One of these two members was the owner co-chair of this team.

> "[The owner co-chair] *wanted* [a specific idea]. *Any other ideas, he said no good. …… Another guy in the team didn't want to put the time study in the research because he said it was too complicated. ……This research should have been very broad. The struggle with these guys, one didn't want to do work sampling or time study and the other guy only wanted to do "lean", was detrimental to this research."*

Another challenge identified through this interviewee concerned about the scoping phase of the research process. The academic interviewee mentioned about his lack of understanding of the CII process.

> *"I didn't understand the CII process. I thought I would have two years for the research. I didn't realize that I really needed to have all research work done in six months."*

The research proposal that the PIs submitted to CII clearly illustrated that the PIs did not have a proper understanding of a typical CII research team process. The research schedule in the proposal showed that the academics planned to 'develop web-based tool' and prepare a final report up till the annual conference where they were to report out. Under the CII publication process, research products are published both in hardcopy and e-copy before when a team reports out, which means any report or tool a team delivers have to be submitted to CII several months before report out.

The other three interviewees, the industry team member interviewees, considered the economic downturn at the time of research as a challenge that this team had to face. They thought that, due to the unfavorable economic situation, it was *"difficult to have face-to-face meetings"* as well as to get *"participation and data"*. Interviewee B said that the team *"partially overcame it, but not fully mitigated that situation"*. He also recalled that the team *"didn't use web meeting technology very much."*

When the interviewees were asked if there were any unique or innovative approaches, Interviewee B considered the subject of data collection and a tool test with target users as innovative.

> *"We interviewed field people, superintendents, foremen, warehouse supervisors, who would be users of the tool we were going to*

develop. That was a little innovative approach……We interviewed people with a prototype tool asking about the use of the tool."

Interviewee D said that the "*overall theme*", the topic, was unique, and added that their "*tool was towards more workers in the field*" compared with "*the other CII research tools – more like executive level tool*".

2.3 RESEARCH METHODOLOGY

Key comments from the interviewees in regard to research methodology are listed Table M8-4.

2.3.1 Scoping

According to the interviewees, the team spent two or three meetings to scope out their research. Interviewee A said that he had thought that the team was "*in a great shape*" at that scoping phase. He noted that "*the team members were aligned very well*" and "*all the team members were on board*" except one member who "*didn't understand*" and, maybe partly because of that, "*just went away after first two or three meetings*".

According to Interviewee B, the contractor co-chair, the team "*came pretty quickly to the agreement*".

> "*Our research data is very minimal for this research project because, once we uncovered the CII document* [previous CII research studies] *that identified these problems, we said "Let's move on from here. We don't need that research.""*

Interviewee C responded that during "*the first two or three meetings*", the team was figuring out what the team was "*going to do, finalizing the charter, and talking about the deliverables.*" Then, he said "*we decided several types of tools that we wanted.*" Interviewee C did not recall any disagreement in this phase because "*the topic was pretty straightforward*" and the team "*knew what it was*". Interviewee D mentioned that the team "*did not try to find any new techniques*" other than existing techniques in the topic related area.

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Industry – contractor co-chair)	Interviewee C (Industry member)	Interviewee D (Industry member)
Alignment around the Scope	• Defined our scope in the second meeting. • We were well aligned except one guy.	• We came pretty quickly to the agreement.	• The first two or three meetings.	• We did not try to find any new techniques.
Scope Change		• It pretty much remained same after we agreed the scope and direction.	• There wasn't a great argument on the research scope or proposal.	• It remained unchanged, same.
Industry Member Background Study	• [The industry members] did not do [background studies].	• Several team members studied and presented previous CII research projects.	• We looked at what other research had done previously.	• The publications of other research teams were reviewed.
Data Collection	• It was not survey-based..	• Interviewed people at jobsites. Three project sties.	• It was basically collecting information.	• Interviews of construction personnel.
Data Collection - Industry Roles	• We let the team people look at their sites and identified problems.	• We went to a couple of construction sites and interviewed people about their interests.		• The PIs and some research team members participated. • We participated in developing questions.
Research Period / Extension		• I think we may have needed more time to develop the tool and to get it completely done.		• We needed more time.

Table M8-4: Research Methodology – Interviews

When asked about the background studies of the industry members in the scoping phase, such as reading previous CII research studies or presenting their company cases, the academic interviewee and the industry member interviewees responded differently. Interviewee A answered that they did not do that kind of background studies saying *"the reason is nobody understood."*

> *"……We ended up talking them about different* [topic related] *techniques. They tried to relate that back to what was done on the site. I made a presentation about* [topic related] *techniques and they gave me feedback about what they thought. That was the way we did that."*

On the contrary, all of the three industry team member interviewees answered that the team did some background studies. Interviewee B said that *"everybody had assignment"* and the team *"gathered information and came back and presented"*. He added that what the team members presented were "[topic related] *techniques* [rather than case studies] *of their companies."* Interviewee B recollected that the team *"looked at what other research had done previously"* to understand *"what do we* [the team] *have in the topic area and what can we* [the team] *pull out."* Interviewee D made similar comments that *"the publications of other research teams were reviewed"*, and, therefore, the team *"made sure we* [the team] *would not reproduce anything done previously"*. This interviewee particularly addressed two benefits of industry background study from his perspective as shown below.

> *"One thing is we were able to see what research had been done. Another thing is to see what was out there and how to use it for our research."*

Other data source that showed the team's background studies was the research project schedule of this team. The research project schedule was included in the first interim report, which was submitted to CII about 5 months after the team started. This schedule included that the team would review *"other CII documents to reduce duplication"* and *"CII Benchmarking data"*. Whether the members actually did this review or not was now known since other data sources, such as meeting minutes, were not available. Nevertheless, it is clear that at least the team planned to review other relevant research studies and existing data. In addition, this interim report noted that the team shared *"current success stories"* of their companies, which could be considered as industry members background studies.

> *"The team members are continuing to report tools that have been successfully used in their companies to address problems in each of the five branches. Currently, the following data has been collected and documented."*

2.3.2 Data collection

Table M8-5 shows the Post RT Survey responses of this team to the questions related to data collection. All the survey participants responded positive with no one responding 'Disagree' or 'Strongly Disagree'.

Survey Question	Responses	Comment
The team had an appropriate and well organized data collection plan.	• A total of 4 responses • 'Strongly Agree' – 1 • 'Agree' – 2 • 'Neutral' – 1	• From my perspective, the data collection plan on this project was to identify IE techniques that apply to construction problems and to get voice of the customer on how the software should work. That's not typical data collection, but was well organized.
The data collection plan was well executed.	• A total of 4 responses • 'Strongly Agree' – 1 • 'Agree' – 2 • 'Neutral' – 1	• No comments provided.
There was strong CII member support in the data collection effort.	• A total of 4 responses • 'Strongly Agree' – 1 • 'Agree' – 1 • 'Neutral' – 2	• Spotty, due to a travel restrictions, but the team members that could picked up the slack. • We really did not collect enormous amounts of data.
The quality of data collected and overall research met my expectations.	• A total of 4 responses • 'Strongly Agree' – 1 • 'Agree' – 1 • 'Neutral' – 2	• See comment on question on previous page about amount of CII support for data collection.

Table M8-5: Research Methodology – Post RT Survey Responses

The research summary and the implementation resource of this team have not been published and meeting minutes were not provided either. The only available source that could provide some insight into the data collection and analysis process of this team was research report and two interim reports submitted to CII besides the interview data. Furthermore, theses limited data did not specifically address data collection and analysis

process. For instance, the research report does not have separate chapter or section to describe the data collection and analysis process of the research.

According to the second interim reports, which narrates about the data collection to some degree, the team would collect *"knowledge and expertise"* from the team members and would interview *"selected experts"* to supplement that *"knowledge and expertise"*.

> *"Although previous CII research seems to be survey-based, the research team concluded that it would be difficult to achieve the goals identified in the charter using a survey instrument. Instead, it was concluded that the knowledge and expertise of the team members would be exploited and supplemented, when needed, by interviews and communications with selected experts from the companies employing the industry members."*

In regard to the data collection effort, Interviewee A said that the team *"took a different approach"* because he thought that construction people were not familiar with the techniques that the team wanted to explore.

> *"……it was not a survey-based. We couldn't do a survey that people didn't know about. So, we took a different approach. There's no traditional CII survey data in the report……How do we validate the process? We let the team people look at their sites and identified problems that we could match* [topic related] *tools through the theory……Industry people identified problems on the site* [problem identification chart], *and we explored these things down and finally got fundamental problems."*

However, it was found in the research proposal submitted to CII by the PIs that the PIs originally intended to conduct a survey in addition to interviews with subject matter experts as research approach and method for their research. The details of how the research approach in the original proposal changed over the course of the research was not known. Nevertheless, the team conducted interviews even though it is unclear that this interview was the data collection method of this team.

The 3 industry member interviewees commonly mentioned that the team members interviewed jobsite personnel. Target interviewees were *"potential users"* of the tool that the team was developing, and the *"PIs and some research team members participated in the interviews"*. This was confirmed by the first interim report.

> *"……team members are interviewing personnel on their sites regarding the appropriateness of the root problems, what information would need to be provided for them to use the tool in the field, and how they would like for that information to be presented."*

A detailed research project schedule posted on the CII SharePoint website of this team illustrated that the team would develop tools first and would collect data on the tool's implementation results. The research report of this team explained the research approach that "[the topic related problems] *were identified and analyzed by subject matter experts' who were members of the team as well as employees of other CII companies who we interviewed."* In regard to design of the tool that the team developed, the research report noted that *"representatives of the target audience were routinely asked to provide feedback on the material being developed regarding, level of content, language, color, format, interface – anything that could be done to make the tool more usable"*, which was called *"user centered design"*.

Interviewee B said that the team interviewed with *"people in jobsites, three project sties"*. He further explained the reason for why the team did not pursue further data collection (e.g., visiting more project sites) as quoted below.

> *"We interviewed people in jobsites in* [State A], *we interviewed some project management and construction management people in* [State B], *and then we interviewed some people I think it was either* [State C] *or* [State D]. *Those three project sties. Each of those three groups gave similar feedback. The information they were giving us was practically the same. Then, we decided that there wasn't a need to go more. You know, sample was three, and all three had about the same information, in fact. So, it wasn't a big disparity."*

One notable point that Interviewee C made was that these interviews were closer to gathering information on what the team was developing. Interviewee C said that *"there was not really data collection. It was basically collecting information."*

> *"It was a collection of processes and tools, something like that within their companies……It was just looking through things that we've had, things we've have been successful in our companies. Bring them together, getting the pool of information together from there……It wasn't a case study in particular. It was a pulling of information. Maybe* [this team] *really isn't research. Maybe that's an issue, I don't know."*

To the question asking the industry members involvement in data collection, Interviewee A mentioned that the industry team members were involved in other process as well besides participating in interviews.

> *"We got the team members engaged in identifying problems in the problem identification chart. The group of people was not* [composed of] *researchers.* [Every member of] *my team was operational person. I gave them a very specific task to do. Making face-to-face meetings very*

scheduled was extremely important. Being very prescriptive in giving tasks to them. It was extraordinary important to get their input."

2.4 TEAM DYNAMICS

2.4.1 Team participation

Key comments from the interviewees in regard to team participation are listed Table M8-6.

The interviewees perceived the team as diverse in terms of age, experience, and industry types. Most of the team members were *"project-oriented"* and *"project management"* people. The diversity of this team, however, became *"less diverse"* as the team *"lost members."* Interviewee D pointed out that *"it would have been easier to have more people with pure construction backgrounds"* rather than people with other industry backgrounds since the members were *"not a lot of from strictly construction"*. He further explained that the team would have needed to *"know what issues in construction are"* since the research was not intended to be *"something just theoretical."*

All the interviewees thought that the team had *"good participation"* and members were *"interested"*, *"committed"*, and *"engaged"*. However, as people had *"travel restrictions"* due to economic situations, people gradually participated less, and eventually *"half of the original team dropped out."* Interviewee A recollected that *"there were several face-to-face meetings"* where the team had *"only six people or so due to the economic downturn"*. He added that *"the other people basically dropped out"*. His interviewee thought that *"six or seven people were active"* on this team. Interviewee B said that *"ten people participated in the conference presentations."* Interviewee D also answered *"ten people"* when asked the number of core people. This interviewee mentioned that *"the core group made all the meeting"* and *"they were very active"*.

Since most of the meeting minutes of this team were unavailable for the analysis, the exact numbers of team attrition and meeting attendance were unknown. However, the research team submitted its meeting attendance record during the last six months to CII. According to these records, the team had 3 face-to-face meetings and 8 conference calls during the last 6 months. The average number of attendees of the three face-to-face meetings is 10, and the average attendees for a conference call meeting were 5. Even though it is not known from these records whether all of the 2 academics and a graduate research assistant attended and counted as meeting participants, it will be reasonable to assume that they did. Therefore, strictly for the last 6 months, 5 to 6 industry members plus the academics participated in face-to-face meetings on average. This number is close to what the interviewees recollected as *"active"* and *"core people"* as mentioned above.

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Industry – contractor co-chair)	Interviewee C (Industry member)	Interviewee D (Industry member)
Team Composition	• We had people with 4~5 years of experience in [topic area] and people with many years of experience in project management.	• They were project managers. • Mid-thirties to mid-sixties.	• A good mix in terms of age. • From five to ten years to 40 years of experience. • Mostly project-oriented people.	• Ages were spread out. • We needed more on the construction side.
Team Diversity		• Having diversity allowed us to explore various ideas.	• Far more divers in the industry perspective.	
Team Attrition & Meeting Attendance	• Half of the original dropped out. • Had several face to face meetings where we had only six people or so.	• We started with 21 people and we ended up with 11 members. • Economic situation – travel restrictions.		

Table M8-6: Team Participation and Commitment – Interviews

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Industry – contractor co-chair)	Interviewee C (Industry member)	Interviewee D (Industry member)
Core Group	• Six or seven people were active.	• Ten people participated in the conference presentations.		• Ten people – they were very active.
Participation & Commitment	• In the beginning, everybody was very committed and was going to come to every meeting.	• People were very interested. • Good discussion and good participation.	• Good participation. • Most of the team members were committed and engaged.	• The overall team participation was poor.
Factors for Participation & Commitment	• It has to be face-to-face meetings if you want people to participate.			• Companies of the team members are most important.
Subgroups	• We divided folks into two subcommittees. • Ad-hoc basis.	• No, we didn't really find a need for that. • We assigned people to certain duties.	• Subgroups met several times separate from the whole team meetings.	• It was early on – we broke out different portions and brought back to the overall meeting.

Table M8-6, continued.

The following interview questions participation illustrates some important factors for member participation from the interviewees' perception. Interviewee D regarded *"support and attitude"* of team member companies as most important. Similarly, Interviewee A made a relevant comment about the co-chairs. He mentioned that the contractor co-chair had the right support from his company (e.g., travel money) while the owner co-chair did not, and, consequently, the owner co-chair became less involved. Interviewee A emphasized the importance of face-to-face meetings as below.

> *"You cannot stay engaged on the telephone. You can't stay with it regardless of how interested you are. So, that's what happened. Some of the members tried to participate on the telephone, finally they stopped. It has to be face-to-face meetings if you want people to participate."*

In regard to a subgroup approach, this team used an *"ad-hoc"* basis when needed rather than an approach formally designed from the start. Interviewee D said that team *"broke out different portions and brought* [the input] *back to the overall meeting."* Subgroups met separately, either in-person or via conference call, but Interviewee D recalled subgroups had conference calls most of the time. One of the Post RT Survey respondents responded to the question addressing meeting frequency indicating that *"sub-teams meeting more frequently as appropriate"*.

2.4.2 Leadership

Key comments from the interviewees and Post RT Survey respondents in regard to leadership are listed Table M8-7 and M8-8, respectively.

2.4.2.1 Industry and academic leadership

Interviewees A and B regarded the leadership of this team as mixed and balanced whereas Interviewee D viewed it as more academic-led. Interviewee A perceived the academics and the industry core group provided leadership in different aspects. He said that most of research related ideas came from the lead-PI interviewee himself while the core group of industry members provided leadership to *"get the work done"*.

> *"I think it was a pretty good mix. I would say, strictly ideas, most of them came from me. I've done research for 20 years, and I know what I am doing. I did that. …… As far as who got the work done, I thought it was pretty amazing because it wasn't me at all.* [The contractor co-chair] *provided a lot of leadership. Of the eight or ten people there including* [the two PIs], *there were very few followers within that group. All of the core team provided leadership. In that regard, it was unique."*

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Industry – contractor co-chair)	Interviewee C (Industry member)	Interviewee D (Industry member)
Leadership	• A pretty good mix. • [The contractor co-chair] provided a lot of leadership. • All of the core team provided leadership.	• Half and half.		• Academic-led. • Our PIs were more direct, and our chairs were laid-back.
Chairs	• [The contractor co-chair] – a very good and effective industry chair. • [The owner co-chair] didn't have much leadership capabilities.	• Good relationship. He (the owner co-chair) was the primary co-chair to begin with. However, I ended up being more involved.	• The chairs took that role – keeping things moving.	• They were not demanding. • I think we needed stronger chairs.
Two Chairs		• It brought both the owner and contractor perspectives.	• It's good to have someone from the both sides. It is the right way to go.	

Table M8-7: Team Leadership – Interviews

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Industry – contractor co-chair)	Interviewee C (Industry member)	Interviewee D (Industry member)
PIs			• [The lead-PI] was less experienced, opinionated. • [The co-PI] was a senior academic, and he did less hands on.	• The lead PI - More aggressive, more direct. • The two PIs worked well together.
Expectations established by chairs		• I did not try to encourage them to attend or participate or whatever.		• They did not [established the expectations].
Leadership Communication	• [The co-PI] and I communicated with the co-chairs.	• Leadership meeting: in prompt. Not scheduled formally.		
Leadership Roles & Responsibilities	• No, except for report-writing.	• We didn't define writing roles and responsibilities between academic and industry.		• That was team effort.

Table M8-7, continued.

Survey Question	Responses	Comments
The Principal Investigator(s) (team academic(s)) did a good job of structuring and facilitating this research.	• A total of 4 responses • 'Strongly Agree' – 2 • 'Agree' – 1 • 'Neutral' – 1	• Great attitudes and drive for the research...Were very helpful in this manner. Lacking in ability to facilitate the team vs. letting the team facilitate them.
The Co-Chairs provided the expected leadership necessary for team success.	• A total of 4 responses • 'Strongly Agree' – 2 • 'Agree' – 2	• No comment provided.
The academic support (development of methodology, facilitation, data analyses, meeting support, etc.) was appropriate and met my expectations.	• A total of 4 responses • 'Strongly Agree' – 2 • 'Agree' – 1 • 'Neutral' – 1	• No comment provided.

Table M8-8: Team Leadership - Post RT survey

Interviewee B commented about the leadership in a similar way. He said that *"the first half of the effort, it was driven by the PIs"*, and *"the second half was more industry driven"*. However, Interviewee D perceived it differently. He said that *"it was more academic-led"*, and *"more driven by the PI"*. When asked what he thought the reason behind that, he answered as below.

> *"I think it was the way it laid out. The topic was already established. I think we had a lot of members who had not been on research teams, so I think it went to the academics who had already established what we were going to accomplish. The proposal was already established……we just relied on the PIs."*

Interviewee C said that *"it's best if academics lead the team"*. He thought that *"the academics of* [the team] *didn't"* take leadership *"due to lack of experience"*. He added that the academics of this team *"weren't strong compared to"* the academics of the other CII research team on which he was participating.

> *"Industry people are project-based. Sometimes, we don't have enough time to do that. If academics keep things moving, I think, it is better. Industry people are bound to their jobs. Jobs are their priority.*

Academics have even load, so they are better than us in scheduling work and keeping things on track."

Next interview question addressed the styles and personalities of the PIs and the co-chairs. Interviewee D characterized the co-chairs as "*laid-back"* and "*not micro-managers"*. He further commented that the team *"needed stronger chairs"* when he was *"looking back."* On the other hand, this interviewee described the PIs as "*more aggressive"* and "*more direct"*, which he thought "*helped accomplish goals"*. Interviewee B said that the chairs took the role in *"keeping things moving"*.

Interviewee A, the lead-PI interviewee, said that the contactor co-chair was *"a very good and effective industry chair without a doubt"*. He described the contract co-chair as "*very senior with tremendous experience"* and "*an experienced team consensus builder"*. On the contrary, the interviewee said that the owner co-chair *"didn't contribute much"*. He added that the owner co-chair *"just didn't have much leadership capabilities"* in his opinion and *"did not have the insight and backgrounds"*.

Interviewee B, the contractor co-chair, said that he and the owner co-chair had a good relationship. He mentioned that the owner co-chair was *"the primary co-chair"* when the team started. However, Interviewee B said *"I ended up with being more involved"* because the owner co-chair had travel restrictions. Interviewee A provided his perception comparing travel issues associated with the two co-chairs in terms of their company positions. This interviewee said that the owner co-chair was in a relatively low level in his organization, so he had no travel money whereas the contractor co-chair "*had a right background and company support"* because he was *"a more senior guy"* in his company. Interviewee B also mentioned that his company supported him very well.

With regard to the styles and personalities of the PIs, Interviewee C commented that the lead-PI "could *have been strong from the organizational side"*.

"*The lead PI has some experience with industry people, consulting experience. But, the consulting is not same as working with industry people. This team was the first CII research team he was on. He could have been strong from the organizational side. I think CII's directive was probably for him not to be stronger. I think he was doing what he perceived what CII was aiming at. But I think it* [PI leadership] *should have been a little bit tighter, stronger; gluing things together."*

The Interviewee C further provided his views in regard to the personality of the lead-PI providing comparison with the PIs of other team on which he was participating.

"*He has very strong personality, and he is very opinionated. But what I am saying is that* [the PIs of other research team he was on] *make sure everything is going smoothly and keep things moving.* [The lead-PI of

this team] *did not do that. His opinion was that he wasn't supposed to assume that role,* [per CII guidance] *I think."*

Interviewee C also commented about the co-PI of this team. He said that the co-PI *"was a senior academic, and he was less hands on"*. This interviewee added his opinion about leadership in general saying that *"leadership is not telling you what to do but having influence on you"*.

2.4.2.2 Leadership roles and responsibilities

When asked if the co-chairs established expectations about team performance, Interviewee D said "they did not". To the immediate following question asking if the team had any grounds rules, Interviewee D responded *"yes"* adding that the team *"described that in the first meeting"*. These ground rules were established and included in the team charter as 'Team Expectations' that describes ground rules and expectations in regard to meeting participation, meeting operation, communications, and member responsibilities. When Interviewee B, the contractor co-chair, was asked the same questions, if the co-chairs, including the interviewee himself, established any expectations, the interviewee provided his viewpoint as quoted below.

> *"Let's put it this way. They are all grown individuals. If they all volunteered for this team, it was my expectation without putting in writing that they would participate. I did not try to encourage them to attend or participate or whatever. They have free will. If they want to participate, they will. To briefly answer your questions, we didn't set any expectations. ……I had expectations in my mind that I feel a responsible individual would have. That's what I went by."*

When asked if the co-chairs and the PIs separated their roles and responsibilities, Interviewees A and B commonly answered that they did not. Interviewee A said that the PIs *"communicated with"* the co-chairs and they *"operated as a group together as opposed to dividing up roles and responsibilities"*. Interviewee B also said that they *"didn't define in writing roles and responsibilities between academic leadership and industry leadership"*. He further commented that the lead-PI *"led the academic part"* and he *"ended up with a sort of a leader for the industry side"*. He added that they "didn't work in a vacuum" because the lead-PI and he *"communicated in between meetings and talked about different things"*.

When asked his opinion about the main differences between the PI and Chairs of the team in terms of leadership, Interviewee B thought that the industry leadership was more *"administrative"* compared with the academic leadership which was more on the research side as provided below.

"The industry leadership maybe more focused on time and schedule, and it seemed to work very well. We very rarely finished meetings with things hanging unanswered or un-discussed.…Our leadership was more of administrative and team organization rather than anything else."

"The PIs did a very good job in addressing what [topic related] techniques could be utilized to solve these problems in addition to being the leader of the [people with topic related expertise and knowledge] in the team. There were three members with [that] *backgrounds – a lot of talent in that regard. They did a god job of leading us more to the solution to make and to provide for the industry. They did a good job of guiding us in that direction."*

To the same question, Interviewee D answered *"That was team effort."* He said that it was *"more like sharing responsibility"* rather than splitting roles and responsibilities.

With regard to the CII's approach to nominate two co-chair on a research team, one from the owner side and the other from the contractor side, Interviewees B and C perceived it as good and necessary to have both perspectives in research. Interviewee C strongly felt that CII research teams *"really need to have both sides"* mentioning his work experience in both owner company and contractor companies.

"You have got very different thoughts, directions, and goals from the owner and contractor sides. It's good to have someone from the both sides. It is a right way to go. If you didn't do that, I suspect we would probably have more contractor members than owner members, and that's not what you want. They have very different goals."

Unlike these two industry interviewees, Interviewee A perceived it differently as quoted below.

"I don't really have an opinion. I don't think this research topic had much difference between owner and contractor. Maybe if I had had a strong owner chair, it would have been different."

2.4.3 Team communications

Key comments from the interviewees and the Post RT Survey respondents in regard to team communication are listed Table M8-9 and M8-10, respectively.

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Industry – contractor co-chair)	Interviewee C (Industry member)	Interviewee D (Industry member)
Team Relationship	• No conflict between owners and contractors.	• I don't think we had conflicts.	• The team members didn't have enough chance to know each other due to the economic issue.	• Good relationships. • I don't recall any (conflicts).
Alignment Process		• More or less consensus based on discussion.		• We didn't really have problems.
PIs & industry members	• Working with the co-chairs - It was great	• Good, cooperated well.		• They were very good.
Social Activities	• Team dinners	• Dinner	• Team dinners	• Dinner
Team Communications	• Phone calls and email a lot. • Face-to-face meetings are by far most important. • I think we used them very effectively.			• Conference calls, web meetings, face-to-face meetings
Team Operation & Management	• I did that with my research assistant. • I kicked off every meeting with the status report		• Academics didn't do much.	• Meeting organization – the PIs and the co-chairs

Table M8-9: Team Communications – Interviews

Survey Question	Responses	Comments
The research team was properly aligned throughout the project.	• A total of 4 responses • 'Strongly Agree' – 1 • 'Agree' – 2 • 'Neutral' – 1	• This team had difficulty finding in getting clear on our purpose. This was made difficult by the travel restrictions that many team members had, so the team had trouble getting a quorum together. The work by the Chairs was outstanding to overcome this. • The team went through the usual stages of a successful team - Form, Storm, Norm and Perform so there was a period of low productivity during the first months the team was assembled.
The research team got off to a good start.	• A total of 4 responses • 'Strongly Agree' – 2 • 'Disagree' – 2	• I think the start was slow. See previous question and comment.
The research project plan and schedule were communicated and agreed to before significant work began.	• A total of 4 responses • 'Strongly Agree' – 1 • 'Agree' – 2 • 'Disagree' – 1	• We developed schedules but they always were revised and not really monitored for attainment of milestone events.
What was the research team meeting frequency (both face-to-face and by phone/web?)		• Face to face - quarterly. Web - monthly. • Budget constraints had a major impact on team members. • Face to Face was every other month. Months that we did not meet face to face were substituted with a phone/web session. Sub-teams meeting more frequently as appropriate.
The research team meeting frequency (phone, web, face-to-face) was appropriate and efficient.	• A total of 4 responses • 'Strongly Agree' – 1 • 'Agree' – 1 • 'Neutral' – 1 • 'Not Answered' – 1	• Phone meetings were OK, but web meetings were difficult. In most cases the companies hosting the meeting did not have the technology or the fire walls prohibited the meeting.

Table M8-10: Team Dynamics - Post RT survey

2.4.3.1 Team Relationship and Alignment Process

The interviewees responded that the team members had *"good relationships"* and there were not any conflicts among the team members. Interviewee B said that the team members *"understood"* what the team was doing would *"benefit"* themselves. Interviewee D mentioned that the team tried to accomplish the goals of the team, and the team members had *"mutual respect for each other"*.

Interviewee C particularly emphasized the importance of building strong relationships as below.

> *"The team members didn't have enough chance to know each other due to the economic issue. If you know somebody really well, you don't want to let them down.……If you build strong personal relationships and you know people well, you produce better products. It's important to support each other with your experience."*

When asked about the alignment process of the team, Interviewee B said that the team *"generally did with open discussions"* and reached *"consensus based on discussions"*. This interviewee recollected that the team did not have alignment issues except when one member raised the issue of research time. The interviewee further explained that this member did not feel that the team had enough time to do what the needed to do. However, the interviewee said that the team *"more or less came to the agreement"* regarding this research time issue.

2.4.3.2 Team Meeting

Based on the comments provided in the Post RT Survey responses, the team had face-to-face meetings bimonthly or quarterly and monthly conference calls in between face-to-face meetings. One survey respondent commented that sub-teams met more frequently. Interviewee D also said that the team *"would meet as needed in subcommittees in between"* the whole team meetings.

The team meetings were organized by the PIs and the co-chairs according to Interviewee D. Interviewee A said that he and his graduate research assistant prepared meeting agenda and kept meeting minutes. He further commented that he would *"prepare a status report for every face-to-face meeting"* and *"kicked off every meeting with that status report"*. Then, he said *"subgroups took over depending of meeting topics."*

2.5 PRODUCT DESIGN AND DEVELOPMENT

Key comments from the interviewees and the Post RT Survey respondents in regard to research products are listed Table M8-11 and Table M8-12, respectively.

This team developed one RS and one tool, and the IR was drafted by the PIs. However, only the RS has been published by CII since the team reported out at the CII Annual Conference.

One of the reasons behind this delay in publication process, believed by the interviewees, is communication between the team and CII in regards to the computer software tool that the team developed. When asked about the quality of the deliverables that the team produced, Interviewee A regarded it as *"outstanding"* and *"useful"*.

> *"Outstanding from my perspective. It is useful. We asked people about everything, and we gave them a prototype. They reviewed and provided input. We built the tool exactly from their specifications. Not only was the content technically accurate, but the tool built was designed for the users from the beginning. So, the tool is outstanding."*

Interviewee A considered the tool as *"user-friendly"*, and Interviewee B characterized the tool as *"very effective"* and *"very easy-to-use"*. Key considerations in developing the tool were *"make it simple, make it easy-to-use"*, as Interviewee D said that was feedback from field personnel. This interviewee commented that the industry team members provided feedback and input and reviewed the products. Interviewee B also said that *"the RS was written between"* him and the lead-PI and *"the other team members reviewed and provided comments"*. Interviewee A also made similar a comment that the team members *"reviewed and provided input to make sure the tool was appropriate"*. In addition to that, Interviewee A described what the industry members did in the tool development process.

> *"They did everything. They developed the flow chart. They came with the six major areas that were sources of the inefficiency of the jobsite. They decided it to be strictly for personnel on the jobsite. They did brainstorming and broke down to the elemental.…..When we started matching the elemental problems with* [the topic area], *I did that. I did all that."*

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Industry – contractor co-chair)	Interviewee C (Industry member)	Interviewee D (Industry member)
Research Products	• Usability and user-friendly.		• I believe information is all there.	• Very effective. Very easy-to-use.
Industry Involvement	• They did brainstorming. • They reviewed and provided input. • [The contractor co-chair] wrote the RS.	• The RS was written between me and [the lead-PI].		• We were providing feedback. People reviewed the products.
Key Considerations		• Intuitive, easy for someone to use.		• Make it simple, make it easy-to-use

Table M8-11: Research Products – Interviews

Survey Question	Responses	Comments
The research project deliverables (Research Summary and Implementation Resource, if appropriate) were most suited to improve performance of CII member companies.	• A total of 4 responses • 'Strongly Agree' – 3 • 'Agree' – 1	• No comments provided.
The topic and research conducted were consistent with what I initially expected.	• A total of 4 responses • 'Strongly Agree' – 1 • 'Agree' – 2 • 'Neutral' – 1	• Strongly agree that topic was very suited for improvement of Construction Industry. Research conducted was not to the level expected. Perhaps due to the need to narrow focus a bit more.

Table M8-12: Research Products - Post RT survey

The next interview question was about alignment issues or conflicts experienced during the research process. Interviewee B answered that the team did not have any conflicts. However, he said that the main alignment issue was between the team and CII. He recalled that CII said *"That software won't work."* to the team when the team submitted their computer software tool. He further argued that if CII was *"really going to feel that way, they should have spoken up earlier in the process"*. He strongly felt that CII *"should have told us* [the team] *that* [software would not work] *from very beginning"*. He considered that it was the key issue of this research that the team *"had dedicated people, invested a lot of time, and didn't have outcome"*.

> *"Draw a line in the sand. I don't know why it took so long for them* [CII] *to actually say "Okay, we will not accept that product. You have to find another software base to do it on." If that was a given thing, we would have taken a different approach. He* [the lead-PI] *and I briefly talked about that."*

Interviewee A, the lead-PI interviewed, also expressed disappointment and frustration in associated with the publication process of the tool when asked why their products had not been published yet.

> *"What we sent out was an interactive computer tool. It was a tool designed for people on the jobsites. We incorporated with comments and needs of the people on the jobsites. CII took it to the PRB. The first comment I got was that the language was not professional enough. For two years, I had been saying we were going to do this for people on the jobsites. We interviewed them and we asked about what they wanted. They wanted simple language.……They rejected three times. I spent a lot of time to improve the tool. After the third rejection, I gave up, and I had converted to a 200-page report.……It's been by far the most agonizing, frustrating, and worst project I have ever done."*

The Annual Conference Survey is conducted every year at conference to assess how attendees perceive presentation performance and value. Analysis of this provides attendee rating on each presentation at a conference including research team presentation. The survey analysis of the year that this team reported out indicated that this team ranked 4th out of 8 research teams reporting out. This rank was based on the combined rating of the plenary session presentation and implementation session presentation. When the ratings of the two presentations were analyzed separately, this team ranked first in the plenary session presentation, whereas ranked 7th in the implementation session presentation.

Appendix M 9

Individual Case Description Report

Atypical Case: A3

Table of Contents

List of Tables

1. Introduction

1.1 CASE INFORMATION

The general information of A3 is summarized in Table M9-1.

Case Category	Atypical		
Project	Project period	2 years	actual: 19 months
	Kickoff date	Mid-December	
	Reporting out date	End of July	
Industry Chairs	Number of chairs	2 co-chairs	
	Change in chairs	No	
	Previous CII experience	No (owner co-chair) Yes (contractor co-chair)	
Principal Investigators (PIs)	Number of PIs	2 PIs	
	Change in PIs	No	
	Previous CII experience	Yes	
Team members	Number of members (excl. academics)	Kickoff: 17	Owner: 7, Contractor: 10
		Report out: 18	Owner: 8, Contractor: 10
	Number of industry members with previous CII research team experience (excl. chairs)	3	2 – one team 1 – two teams 1 – three teams
Research Methodology	Research Method	Quantitative	Statistical analysis
		Qualitative	Case studies
	Validation Process	Hypothesis Validation	
Products	Products published	Research Summary: 1	
		Implementation Resource: 0	
		Research Report: 1	

Table M9-1: Case Information

1.2 DATA SOURCES

The main data source for this case study was individual interviews with 4 members of this team. Other data sources to support and/or supplement the interviews included CII Post Research Team Survey (Post RT Survey) responses of this team and

CII documents and archival records. The detailed data sources and their availability for analysis are summarized in Table M9-2. All the available sources in Table M9-2 were analyzed to investigate the case from multiple perspectives. Words, phrases, and sentences in italic font with quotation marks in this case description indicate direct quotes from the interviews or comments of the Post RT Survey respondents.

Data Type	Data Source		Available and used for analysis
Interview	4 interviews	2 academics	
		2 industry team members	
Documentation	Team documents (retrieved from CII SharePoint)	Research Topic Statement	Yes
		Proposal	Yes
		Charter	Yes
		Meeting agenda	No
		Meeting minutes	3 face-to-face meeting minutes 2 conference-call meeting minutes
		Interim Reports	Yes (1 report)
		Team roster	Yes
	Research products	Research Summary	Yes
		Implementation Resource	No
		Research Report	Yes
Archival Records	CII surveys	CII Post Research Team Survey	Yes
		Annual Conference Evaluation Survey	Yes
	CII records	CII product usage - Hardcopy sales and e-copy downloads numbers	Yes
		CII team meeting attendance records	Yes

Table M9-2: Data Sources

1.2.1 Interviews

For this team, 2 academics and 2 industry members were interviewed. The 2 academic interviewees worked together on a CII research team prior to this team, and one of the industry member interviewees had participated on 3 CII research teams before this

team. This industry interviewee was also participating on another CII research team at the time of the interviewee. The other industry interviewee had no previous CII research experience.

Each interview was conducted on a one-to-one basis at a different time and place. Interview durations ranged from 0.5 hour to 1.5 hours depending on interviewees' time availability. Dialogues of all the interviews were digitally voice-recorded upon the written consent of the interviewees.

1.2.2 CII Post Research Team Survey (Post RT Survey)

A total of 4 industry team members of this team responded the CII Post RT Survey. The Post RT Survey is sent by CII to every CII research team member after the team reported out at a CII Annual Conference. The survey analysis considered the ratings and comments that the respondents provided in a narrative form. Since only a small number of the team members responded, any statistics on the respondents' ratings based on a five-point scale were only regarded as referential.

1.2.3 Other Data Sources

Other data sources collected and reviewed for this case were team documents and CII archival records relevant to this case. The team documents included the research topic statement provided to this team by CII, the proposal submitted by the PIs to CII, the team charter, meeting minutes, team rosters, interim reports submitted to CII by the team, and the research products that the team delivered (i.e., research summary and research report). The CII archival records included CII Post RT Survey responses, CII Annual Conference Evaluation Survey ratings, and hardcopy sales and e-copy downloads numbers of the research products of this team.

2. Case Analysis

2.1 CASE OVERVIEW

The team had a kickoff meeting in mid-December. The target report out date was approximately after 19 months from the kickoff meeting. The research topic statement was provided to the team with essential questions and potential deliverables. According to the first interim report, which was submitted to CII in its third month of the research process, the team charter was finalized in the second face-to-face meeting.

This team did not experience any leadership changes. The two co-chairs and the two PIs stayed until the end of the research. The contractor co-chair of this team had

participated on a CII research team, and the owner co-chair did not have prior CII research team experience. Both PIs had civil engineering background specializing in construction management.

The team started with 17 industry members, 2 PIs, and 2 graduate research assistants according to the team roster as of the kickoff meeting. Of these initial 17 members, 7 members were from owner companies, and 10 members were from contractor companies. At the time of reporting out, 18 industry members were listed in the team roster which was dated shortly after the team's report out. Of these 18 members, 8 members were from the owner side and 10 members were from the contractor side. This team roster, however, was different from the team members listed in the research summary. There were a total of 17 members listed in the research summary, of which 8 members were owners and 9 members were contractors. One member showing on the final team roster was not listed in the research summary. This particular member did not show on any of available meeting attendee lists.

2.2 STRENGTHS AND WEAKNESSES

Table M9-3 includes key responses of the interviewees to the question asking about strengths, weaknesses and/or challenges, and unique aspects of this team.

The interviewees commonly regarded the experience and dynamics of the team members as one of strengths of this team. Interviewee C particularly noted that the team members had *"20~25 years"* of experience focused on project management. Interviewee D mentioned that it was both strength and a weakness to have handful of very determinant and strong individuals in the team.

> *"We had some really determinant individuals. I think those handful of people really led the way. It was strength of the team and also weakness of the team, I think. Because I don't think everybody was participating."*

The interviewees felt that the research topic given to this team created a challenge. It was a *"tough topic"*, and the *"research topic statement"* given to the team was *"ambiguous"* according to the interviewees. Interviewee B said that *"it was challenge that the research was not exactly defined and coordinated from the beginning to the end"*. This interviewee added that *"there were different thoughts on the proposal and gaps in interpreting the topic"* which consequently brought in some *"difficulties in defining the research scope"*.

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Academic – co-PI)	Interviewee C (Industry – contractor co-chair)	Interviewee D (Industry member)
Strengths	• The research methodology was appropriate. • Team dynamics were generally good.	• Experienced team members.	• Team members with good cross section of experience. • Project management focused experience.	• Some very determinant [strong] individuals.
Weaknesses / Challenges	• Didn't have enough time. • Topic. • Leadership issues.	• The research was not exactly defined and coordinated from the beginning to the end. • The research topic statement was ambiguous.	• People with long project management experience • We had to struggle with getting a direction.	• A tough topic.

Table M9-3: Strengths and Weaknesses – Interviews

Interviewee C mentioned that the team *"had to struggle with getting a direction"* for the research. This interviewee also said that the team members had *"long project management experience"*, and, therefore, they were *"very task-oriented"*, which could be strength. However, he thought that this topic required people *"to be creative"* which these *"left-brain"* people were not good at. He added that if the team had *"had a tool developed"* the team *"would have done very quickly"*.

Interviewee A made a similar comment about the topic nature and *"creativity"*. He mentioned that the research topic statement given to the team was *"unique"* and different from typical CII research projects. Most CII research projects were, in his words, *"designed to solve specific problems or to produce specific tools for the immediate practical use of the industry."* He thought that this uniqueness of the topic *"caused some challenges to the team."* When he was asked what kind of challenges the topic caused, he answered that *"most of the team people didn't really have a background in the research"*.

> *"They were not used to taking on questions that you really didn't have the answer to. The real creativity was required. It was the tendency, especially the chairs, kind of treated us as a normal project, so they were looking for what the clients* [the CII Research Committee] *wanted. It collided with the need for creativity."*

This interviewee mentioned about the nature of the topic several times later the interview as well difficulties caused by the specific nature of the research topic.

Another challenge referred by Interviewee A was a short research period. This interviewee said that *"the research methodology was appropriate"* because *"it was a combination of statistical analysis, literature review and case studies"*. However, he noted that the team *"didn't collect sufficient data points or cases to support statistical analysis"* because of lack of time. He also mentioned that the team had *"leadership issues"*. He said that *"the chairs had never been on CII research teams before"*, which he thought was *"a problem"*. However, CII database shows that one of the two co-chairs, specifically contractor co-chair, had participated on one research team before joining this team.

2.3 RESEARCH METHODOLOGY

Key comments from the interviewees in regard to research methodology are listed in Table M9-4.

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Academic – co-PI)	Interviewee C (Industry – contractor co-chair)	Interviewee D (Industry member)
Scoping Phase	• It was probably in April following the kickoff meeting in December.	• We developed the team charter during the first two months.	• We were still struggling at the midpoint of the research period.	• We were still trying to determine the direction – probably the third or fourth meeting.
Alignment around the Scope	• Even though formally we had an agreement, we actually didn't come to an agreement.	• The team members agreed on the charter, but some suggested different approaches later.		• The alignment was not good after I joined. We were behind schedule.
Industry Member Background Studies	• Shared how their company delivered projects.	• Some members made presentations on their company cases.	• I went back to and read some of the relevant CII materials and research team results.	

Table M9-4: Research Methodology – Interviews

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Academic – co-PI)	Interviewee C (Industry – contractor co-chair)	Interviewee D (Industry member)
Data Collection	• CII BM&M database. • Case studies.	• CII Benchmarking data. • Data from a Ph.D. dissertation. • Qualitative case studies.	• Statistical analysis and qualitative analysis.	• I don't recall the details of the data collection process. I believe that we did some case studies.
Data Collection - Challenges	• Some of them (members) didn't give their case studies.	• CII Benchmarking data did not exactly match what we were trying to do with our research.	• The research team struggled with collecting case studies needed to test the hypothesis.	
Data Collection - Industry Roles	• Case studies: the industry members generally collect within their own companies.	• Case studies	• Team members tried to do within their companies.	

Table M9-4, continued.

2.3.1 Scoping

Interviewee B said that the team *"developed the team charter during the first two months"*. The meeting minutes of the second face-to-face meeting, which was approximately two months after the kickoff meeting, showed that *"the team charter was revised and agreed"*. However, as the interviewees commonly noted, the team still had a struggle to *"determine the research direction"* at *"the midpoint of the research period"*.

Interviewee C recalled that the team *"had a conference call with CII guys* [the CII Research Committee sponsors]*"* at one point to understand what the topic meant because they struggled with the research topic statement. He said that the meetings in the early phase were *"very productive"* where there were *"a lot of sharing of experiences of"* each member in the context of the research topic. Nevertheless, it was not easy for the team to quickly *"gain a focus"* and to establish the research direction because of the topic nature as quoted below.

> *"…… But, it took us a while to really gain a focus where we want to go with this because it is such a broad topic. You can get into a lot different aspects of why a project is not successful."*

Interviewee A and D made a similar notion in regard to team alignment of the research scope. Interviewee A perceived that the team did not actually *"come to an agreement"* even though they formally agreed on the team charter. Interviewee D recalled that the team was *"still trying to determine"* the research direction when he joined the team after the team already had a couple of meetings. He added that he could not remember when *"the team was finally aligned and determined the research direction"*.

> *"Relatively early agreement on the charter. However, there was a continuous concern, especially with the chairs, that we were not doing what the CII Research Committee was expecting us to do. Even though formally we had an agreement, we actually didn't come to an agreement." – Interviewee A*

> *"The alignment was not good after I joined. We were behind schedule. We were still trying to determine the direction even after I came on board – probably the third or fourth meeting. ……I honestly can't remember when the team was finally aligned and determined the research direction." – Interviewee D*

During the scoping phase, industry team members did background studies related to the topic. The minutes of the second face-to-face meeting noted that several industry members made presentations of their company's project experience. This is consistent with what Interviewees A and B mentioned about the background studies conducted by

industry members. Interviewee C also said that he *"read some of the relevant CII materials"*.

2.3.2 Data collection

Table M9-5 shows the Post RT Survey responses of this team related to data collection. Of the 4 respondents, no one responded 'Strongly Agree' indicating less satisfaction with the data collection process.

Survey Question	Responses	Comment
The team had an appropriate and well organized data collection plan.	• A total of 4 responses • 'Agree' – 2 • 'Neutral' – 2	• Having the team develop their own case studies was helpful. • Struggled getting relevant case studies.
The data collection plan was well executed.	• A total of 4 responses • 'Agree' – 2 • 'Neutral' – 2	• No comments provided.
There was strong CII member support in the data collection effort.	• A total of 4 responses • 'Agree' – 2 • 'Neutral' – 1 • 'Disagree' – 1	• Turns out that CII data is hard to evaluate for [teams' approaches to the topic].
The quality of data collected and overall research met my expectations.	• A total of 4 responses • 'Agree' – 2 • 'Neutral' – 2	• No comments provided.

Table M9-5: Post RT Survey Responses - Data Collection

One somewhat unique aspect of this research methodology was that the team developed a *"testable hypothesis"*. This hypothesis was formulated based on the literature review and *"team brainstorming"* according to the research summary and the research report of this team. The team then identified variables and established data collection methods *"to measure the correlations between the variables of the hypothesis"* and, therefore, *"to test the hypothesis"*. The data sources were the CII benchmarking database and case study projects of the team members. In addition to these two data sources, the team used another set of data from a dissertation research of one of doctoral students of the lead-PI. This doctoral dissertation, listed in the references section of the

research report, was a study about the construction industry in the student's native country, and the data were collected from projects in his country.

The *"case studies"* of this team were conducted by the team members using *"a complementary questionnaire survey"* that was developed by the academics. The primary purpose of the *"case studies"* was to obtain data *"in areas where CII benchmarking data was insufficient"* to test the hypothesis because the team discovered that the CII benchmarking database did not include *"all relevant variables"*. The survey questions for the case studies were attached to the research report as an appendix. These questions were a mix of quantitative and qualitative questions. Respondents would answer quantitative questions on a 7-point scale, and would answer the other questions in a narrative format. Analysis methods for the case studies included both quantitative and qualitative analysis approaches as described in the research report.

The interviewees were then asked if the team experienced any challenges during the data collection and analysis process. A couple of common challenges mentioned by the interviewees included first, a compatibility issue between the CII Benchmarking data and the variables that were identified for the hypothesis testing, and second, an insufficient number of case study projects. These two challenges were closely related because the first challenge pushed the team to conduct case studies, which also eventually resulted in the second challenge. Interviewee C also commented that the team first struggled with the CII Benchmarking data because *"not a lot of data were available"* form CII. As a result, he added that the team members tried to use the survey *"within their companies."*

According to the research report, the team identified a number of variables to test the hypothesis. However, they soon found out that they could not find all variables from the CII Benchmarking database. The next step of the team was to reduce the list of the variables that could be analyzed with CII Benchmarking data. The team also decided to conduct case studies to supplement the quantitative analysis because the CII database did not provide any qualitative information necessary for the hypothesis testing. Interviewee A commented that the fact that the CII Benchmarking database did not have data for all the variables was the reason why the team conducted case studies.

In terms of the case studies, the research report noted that *"data were collected on 20 projects"*, which resulted in 20 data points for the analysis. Interviewee A mentioned that the team *"got data from eight or nine different organizations"*. One of the Post RT Survey respondents commented that the team *"struggled getting relevant case studies"* while another respondent commented that *"having the team develop their own case studies was helpful"*.

This lack of data resulted in difficulties in testing the hypothesis that the team established as Interviewee noted when he was discussing the weaknesses and/or challenges of this team.

"We didn't collect sufficient data points or cases to support statistical analysis. The result with regard to that part of the research was indicative, but couldn't really qualify the evidence of that."

2.4 TEAM DYNAMICS

2.4.1 Team participation and core group

Key comments from the interviewees in regard to team participation are included in Table M9-6. Of the 17 members, 4 members were either vice president or president. The rest of the team members were mostly in a manager or director level position. The interviewees generally perceived the team composition as good. Nonetheless, Interviewee A said that the team needed people with more creativity and free-thinking which he thought was what the construction industry lacked.

"The problem here isn't one that would be solved by selecting age, gender, or technical experience……I think the team composition would have been better if we'd had more people who were owners. …… It is something that requires free-thinking. The industry doesn't tend to have those people in abundance."

Interviewee A also mentioned that company positions of the team members created a challenge because the middle management level people did not have proper authority for gathering information.

"Probably the people from the middle-level increased that challenge because they wouldn't have the scope of authority. They didn't have that level of authority to look into someone else to tell them what the problem was to be solved."

In terms of meeting attendance, about 10 industry members attended every meeting on average based on the attendee records of 7 face-to-face meetings with the attendance rate of 61% excluding academics. This number is consistent with the number of active members perceived by the interviewees. The team had core people according to Interviewee A *"came up with ideas, shared their experience, and explored possibilities"*. Interviewee B said that the team had 7 or 8 core members while Interviewee D recollected there were 4 or 5 core people. According to the 5 meeting minutes that were available, 7 industry members attended more than 3 face-to-face meetings, and 12 industry members attended at least 3 face-to-face meetings. *"A couple of people never showed up"*. The industry members denoted as principal authors were 5 people including two co-chairs, which number is very close to what Interviewee D considered as a core group.

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Academic – co-PI)	Interviewee C (Industry – contractor co-chair)	Interviewee D (Industry member)
Team Composition	• A few of them were in high position, and most of them were in middle position.		• A lot of people were project managers, directors, vice presidents, and general managers.	• The team make-up was really good.
Team Diversity	• It is something that requires free-thinking. The industry doesn't tend to have those people in abundance.			• The diversity of the team was actually good.
Participation & Commitment	• About 10 people of active participation. • We lost several people.	• Probably 40% were actively involved, 20 to 30 % were just followed this active group, and the rest 20 to 30% didn't participate at all.	• Originally 19 members. • Average attendance - about 10~12 [per meeting].	• The participation of the team lessened because people were busy and they saw the research was not going anywhere.

Table M9-6: Team Participation – Interviews

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Academic – co-PI)	Interviewee C (Industry – contractor co-chair)	Interviewee D (Industry member)
Core Group	• They came up with ideas, shared their experience, and explored possibilities.	• About 7 or 8 people were very active.		• Several (4~5) strong individuals who actively participated from the beginning drove the direction of the team.
Factors for Participation & Commitment			• We didn't know how we were going to come up with anything real meaningful.	• The rest of the team did not fully agree that direction, but they kind of passively agreed to the core group.
Subgroups	• We didn't have on a continuing basis. • People didn't do the assignments. They were too busy.		• No real frequently. • Preparing the Annual Conference – divide and conquer.	• Most of the meetings I attended were full team meetings. • Divide and conquer – towards the annual conference.

Table M9-6, continued.

One interesting notion made by Interviewee D in regard to this core people was that the core group dominated the team discussion and drove the research direction. He added that the other team members passively agreed and participated in the research.

> *"……They dominated the discussions. The rest of the team participated, but since the whole team struggled with the research direction the core group of people kind of drove the direction. The rest of the team did not fully agree that direction, but they kind of passively agreed to the core group. That was my impression. The four or five basically decided 'this is what we are going to do.'"*

This interviewee mentioned about this aspect again later in the interview saying that some of team members were strongly aligned with the lead-PI and the rest of the team followed their direction not because the rest of the team agreed the direction but because the rest of the team could not propose any alternative direction or ideas.

> *"……it is really interesting because there were four or five members who were very aligned with* [the lead-PI], *and the rest of the team didn't feel right about the direction. The people who didn't necessarily believe the approach that the team was taken didn't have better ideas about how to finish the research."*

Interviewee C recalled that some members felt frustrated due to lack of accomplishment during the course of the research process.

> *"Midway through, some people were really frustrated because we didn't come up with anything really innovative and we didn't know how we were going to come up with anything real meaningful. In the end, we did. We weren't sure how we were going to get there."*

When asked if the team utilized subgroups, interviewees responded negatively. The team *"divided into subgroups"* to facilitate discussions in several face-to-face meetings, but it was not a formal approach. The team *"didn't have* [subgroups] *on a continuing basis"*. Interviewee A mentioned that the team *"tried to do"* work in subgroups, *"but it didn't work"* mainly since *"people didn't do the assignments"* because *"they were too busy"*. He added that his *"impression was that people were not released from their normal duties sufficiently to do their job for the research"*. When the team approached report out for the Annual Conference, however, they *"divided up"* to prepare presentations and to write the RS in order to *"divide and conquer"* tasks.

2.4.2 Leadership

Key comments from the interviewees and the Post RT Survey respondents in regard to leadership are presented in Table M9-7 and M9-8, respectively.

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Academic – co-PI)	Interviewee C (Industry – contractor co-chair)	Interviewee D (Industry member)
Leadership	• It was really academic-led.		• A good balance. • We did struggle with leadership, initially. In the end, [the owner co-chair] really stepped up and drove the team to get things done.	• The academics led the team – slightly more.
Chairs	• The chairs of this team didn't do anything. • They both seemed that they felt uncomfortable in this research environment.	• [The contractor co-chair] was not so active. • [The owner co-chair] did well. He was flexible.	• [The contractor co-chair] took an important position and he was totally occupied with his job. • [The owner co-chair] took the leadership role.	• [The contractor co-chair] was particularly busy. He did not participate in all the meetings. • [The owner co-chair] struggled with the leading roles and responsibilities.

Table M9-7: Team Leadership – Interviews

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Academic – co-PI)	Interviewee C (Industry – contractor co-chair)	Interviewee D (Industry member)
PIs	• He and I worked together before. We worked together quite well.	• The relationship between the co-chairs and the PIs was good.	• Lead-PI: has more experience. Part of that he brought was geared toward what he had done outside this research team. • Co-PI: He provided good input, but he was not a strong leader.	
Leadership Communication	• Not regularly or separately.			
Leadership Roles & Responsibilities	• [The owner co-chair] made some contributions during the team discussions, but mostly he was not very active.		• Not really. • Meeting facilitation: Mainly [the lead-PI].	

Table M9-7, continued.

Survey Question	Responses	Comments
The Principal Investigator(s) (team academic(s)) did a good job of structuring and facilitating this research.	• A total of 4 responses • 'Agree' – 1 • 'Neutral' – 2 • 'Disagree' – 1	• There really wasn't as much research as I might have expected, due to the nature of the project.
The Co-Chairs provided the expected leadership necessary for team success.	• A total of 4 responses • 'Strongly Agree' – 2 • 'Agree' – 1 • 'Neutral' – 1	• Especially [the owner co-chair]. He really stepped-up in the latter months.
The academic support (development of methodology, facilitation, data analyses, meeting support, etc.) was appropriate and met my expectations.	• A total of 4 responses • 'Agree' – 2 • 'Neutral' – 2	• Although I think we could have benefitted from more literature search and review (at least for the industry participants).

Table M9-8: Team Leadership - Post RT survey

2.4.2.1 Industry leadership

Interviewee C regarded the leadership of this team as *"a good balance"* saying that it was *"more of collaborative"* rather than *"one person saying* [providing] *the research direction"* whereas Interviewees A and D described it as academic-led. In terms of industry leadership of this team, the interviewees commonly pointed out that there were some issues with the co-chairs, particularly with the contractor co-chair.

Interviewee C thought that the two PIs and two co-chairs *"struggled a little bit"* with leadership. Interviewee A said that the industry co-chairs of the previous CII research team on which he had participated were *"quite strong"* and they *"organized agendas and meetings"*. He added that *"the chairs of this team didn't do anything"*.

According to Interviewee C, the contractor co-chair, *"took an important position and he was totally occupied with his job"*. Interviewee A also said that the team *"later discovered that* [the contractor co-chair] *was in the process of buying his division and*

turning it into a separate company". Interviewee A added that *"his* [contractor co-chair's] *attention was elsewhere"* and *"that was a challenge"*.

Interviewee B recollected that the owner co-chair *"was flexible"* and *"actively participated"* in the research process. On the contrary, he perceived that the contractor co-chair was *"not so active"* and *"negative"*. Interviewee C recalled that the contractor co-chair was *"negative"* after the dry run of their presentation saying *"no way we can get this done"* whereas the owner co-chair said *"yes, we can get this done"*. He added that the owner co-chair *"took the leadership role"*. One of the Post RT Survey respondents also commented that the owner co-chair *"really stepped-up in the latter months"*. Interviewee D also made a similar notion about the co-chairs. He mentioned that the contractor co-chair *"was particularly busy"* and *"did not participate in all the meetings"*. He thought that the owner co-chair and other three core team members should *"deserve pretty much all of the credits"*. Interviewee A also commented that the contractor co-chair *"made some contributions during the team discussions, but mostly he was not very active"*. In regard to meeting attendance of the two co-chairs, both co-chairs attended 5 face-to-face meetings of which minutes and attendee lists were available. However, both of them did not attend 3 conference call meetings. It is unknown whether they attended the rest of face-to-face meetings and conference call meetings.

Interviewee A made an interesting notion about the two co-chairs. When he was asked about the scoping phase of the team, this interviewee mentioned that the co-chairs had *"a continuous concern"*. This concern, he said, was that the team was not doing what the CII Research Committee was expecting the team to do. When asked what the chairs thought the CII's expectation was, Interviewee A answered he did not really know. His perception was that the co-chairs thought the team was on the wrong track while he thought the team was not. He said that the team *"made choices"* as a team on the research direction. To the following question asking other team members reactions to that, the interviewee recollected that *"there were some mixtures"*, but he said *"most of the team seemed to be happy with the direction we were taking"*.

2.4.2.2 Academic leadership

The two PIs had participated as PIs on the same prior CII research effort. According to Interviewee A, the CII Research Committee asked that Interviewee A *"be the leader"*, because he thought the Research Committee knew that he was *"more experienced"* than the co-PI. Interviewee A said that the co-PI and he *"worked together quite well"* and that *"no alignment issues surfaced"* between the co-PI and him.

Interviewee C described the co-PI as *"more of a researcher type"*. He thought that the co-PI did not have much practical experience. Even though the co-PI *"provided good input"*, this interviewee perceived that the co-PI *"was not a strong leader"*. In regard to the lead-PI, this interviewee commented as below.

> "[The lead-PI] *has more experience. Part of that he brought was geared toward what he had done outside this research team. He tried to not to do that too much. He discussed openly."*

This interviewee commented that the two PIs had *"a very respectful relationship"* and had *"no conflicts"* between them.

2.4.2.3 Leadership roles and responsibilities

Interviewee A said that the two PIs and the two co-chairs *"had leadership meetings"* but *"not regularly or separately"*. He added that they had conversations during the face-to-face meetings as *"side discussions"*. When asked about the roles and responsibilities of the PIs and co-chairs, Interviewee C answered that there were not really separate, distinguishable roles and responsibilities between the academic leaders and the industry leaders. Interviewee A noted that the co-chairs seemed *"uncomfortable"* in the research environment.

> *"They both seemed that they felt uncomfortable in this research environment. I did have a sense that they had received very explicit and structured instructions about their roles and responsibilities as chairs. They kept looking at us* [the PIs] *and wanted us to tell them what to do. I tried to push it back. I should have simply stepped early on, earlier than I did."*

As time approached for report out, Interviewee A said that the co-chairs "ultimately stepped up when we were writing products", and "they began to really try to get people organized and interfaced with CII in regard to administrative things".

With regard to the PI roles and responsibilities, Interviewee A recollected that *"as the work changed, allocation changed"* between the two PIs. According to this interviewee, the co-PI and his graduate research assistant *"were responsible for case study analysis"* and subsequently *"the data analysis from the case studies"* while the interviewee *"was primarily responsible for collecting the data"*.

2.4.3 Team Communications

Key comments from the interviews and the Post RT Survey respondents in regard to team communication are listed Table M9-9 and M9-10, respectively.

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Academic – co-PI)	Interviewee C (Industry – contractor co-chair)	Interviewee D (Industry member)
Alignment Process			• We enjoyed hearing different perspectives. • Time went by quickly and we realized we hadn't accomplished anything.	
Team Relationship	• Very cordial.		• Respectful and collaborative.	
Team Meetings	• The PIs organized the team meetings, prepared agendas, and kept meeting notes. • Mostly I led discussions during the team meetings.	• The lead-PI led the meetings and meeting agenda was developed by the co-chairs.	• I can't remember who took meeting notes. • Academics brought a graduate student occasionally.	• [The lead-PI] did lead the team meetings. The co-chairs did some.
Team Communications	• SharePoint and emails. • We met monthly alternating between face-to-face meetings, web meetings and teleconferences.		• Face-to-face meeting every two months and conference calls in between. • Emails. SharePoint.	
Social Activities	• We had team dinners.		• We always went out to dinners.	

Table M9-9: Team Communications – Interviews

Survey Question	Responses	Comments
The research team was properly aligned throughout the project.	• A total of 4 responses • 'Neutral' – 2 • 'Disagree' – 2	• Struggled to determine whether or not our findings and recommendations were relevant; In the end, the constructive tension was beneficial and helped us come up with the results. • Lots of discussion on our scope and disagreement on our deliverables. Having the conference as a deadline forced a focus realizing we couldn't continue to debate.
The research team got off to a good start.	• A total of 4 responses • 'Agree' – 2 • 'Disagree' – 2	• Though we struggled to develop a focus in the early months.
The research project plan and schedule were communicated and agreed to before significant work began.	• A total of 4 responses • 'Agree' – 2 • 'Neutral'– 2	• No comments provided.
What was the research team meeting frequency (both face-to-face and by phone/web?)		• Face to face at least once/quarter with phone meetings in between. • Met monthly and alternated between f-t-f and phone conferences. • Once a month. Face to face every other month.
The research team meeting frequency (phone, web, face-to-face) was appropriate and efficient.	• A total of 4 responses • 'Strongly Agree' – 1 • 'Agree' – 3	• [No comments provided.

Table M9-10: Team Dynamics - Post RT survey

2.4.3.1 Alignment Process

Interviewee C commented that the team had good discussions sharing experience and exploring ideas of each other. He said that the team *"enjoyed hearing different perspectives"* and it was *"all very good discussion"*. This process can be viewed as *"creative – thinking workshops"* articulated in the research report. The research report stated that the purpose of these *"creative thinking workshops"* was to *"validate the results of literature review"* and *"to vision"* the concept and *"to explore"* ideas in associated with the research topic. This approach was suggested in order to *"think outside the box"* and *"to explore possibilities with the research team"* according to the proposal submitted by the PIs.

In spite of its goals and purposes, including exploring ideas and promoting innovativeness, Interviewee C mentioned that *"it was hard to visualize what the outcome would look like due to broadness of the scope"* and the team realized that they *"didn't accomplish anything"*.

> *"After a while, you got to stop talking about experience and narrowing down to something useful..…… We didn't do much in between the meetings. There were some, but probably not as much as people would like to. There were some accomplishments, but we really struggled with what* [the research topic] *was. The nature of the topic was the biggest challenge."*

A couple of the respondents of Post RT Survey made comments to the alignment question that the team *"struggled"* to connect what they were doing with the topic, and they had *"lots of discussion"* on the scope and *"disagreement on"* the deliverables. Interviewee D also recalled that the team felt their research did not progress to the right direction.

> *"The research topic was very tough. When a CII research team reaches the halfway stage, usually you know what you will come up with is useful or not. When we reached the halfway, we realized that nobody was really going to use it. I remember one senior member from the contractor side said that he didn't think this research was going anywhere. It's a shame because a lot of people spent a lot of time and effort to try to make it work."*

When asked if the team had thought about 1-year extension, Interviewee C answered that they did, but the team decided not to do for another year.

> *"One year extension? We asked ourselves that question. We thought that another year wasn't going to really help us a lot. Three years*

is a long time. I don't think anybody had any interest in doing another year. Travelling every other month for two years is a lot of travelling."

2.4.3.2 Team Meetings

According to the meeting attendance records that the team submitted to CII, the team had 9 face-to-face meetings including the kickoff meeting and 7 conference call meetings during its 19 months of the research period. The team met in even months in person and had teleconference meeting in odd months in between face-to-face meetings. The team meetings were mostly led by the lead-PI, but sometimes the co-chairs led the meetings as well depending on topics discussed during meetings. Interviewee A said that the *"PIs organized the team meetings, prepared agendas, and kept meeting notes"*. Interviewee B recollected that the *"owner co-chair took the responsibility of meeting organization"* and the owner co-chair *"brought his secretary to take meeting notes and to arrange meetings"*.

2.5 PRODUCT DESIGN AND DEVELOPMENT

Key comments from the interviewees and the Post RT Survey respondents in regard to research products are listed in Table M9-11and Table M9-12, respectively.

Interviewee C thought that *"the entire team was concerned about readiness for presenting at the Annual Conference"*. He said that after a rehearsal for the Annual Conference, the team *"voted and determined"* that the team was *"not going to be ready with enough substance for the conference"*. He added that *"once the consequences were realized, the core group worked diligently to drive to meaningful results and a quality report out at the conference"*. Interviewee D perceived that their research did not come up with products practical and useful to the industry as presented below.

"It was tough assignment, very tough deliverables. We struggled with it. For me, it was a little bit disappointment when we went to the wrong direction. Unless we can come up with something useful to the industry, this is my personal opinion, then, what's the point of doing that? I think it was too much, too far away from the reality. Ultimately, the team pulled together well at the conference, but I don't think there is much meat to back it up."

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Academic – co-PI)	Interviewee C (Industry – contractor co-chair)	Interviewee D (Industry member)
Products Quality	• I think what we produced was really quite good.		• Pretty good work and good thought into it. Well written.	• I think it was too much, too far away from the reality. • I don't think there is much meat to back it up.
Key Considerations	• What I had in my mind when I was drafting it was trying make it readable and compelling.		• Tried to make it real practical. • Relevant to both owners and contractors.	
Feedback	• Nothing from CII. • I don't think we have published in academic journals.	• We got feedback that the research findings were too general. So, we added some content.	• None. I have used it occasionally within [the company].	

Table M9-11: Research Products – Interviews

Survey Question	Responses	Comments
The research project deliverables (Research Summary and Implementation Resource, if appropriate) were most suited to improve performance of CII member companies.	• A total of 4 responses • 'Agree' – 4	• No comments provided.
The topic and research conducted were consistent with what I initially expected.	• A total of 4 responses • 'Agree' – 2 • 'Neutral' – 1 • 'Disagree' – 1	• As a team we struggled with the scope of what [topic] meant. Our ideas weren't new but also aren't common practice.

Table M9-12: Research Products - Post RT survey

He additionally pointed out that several strong and active members drove the research direction and brought some results that some of other members thought *"beyond reality"*.

> *"This research focused too much on* [specific concepts of the topic that the team developed] *between project participants, and some of team members felt that was beyond reality. They felt it a fantasy. The real world is not like that. Maybe the industry members have pushed back some of them, but several, four or five strong individuals who actively participated from the beginning drove the direction of the team. The participation of the team lessened towards the team because people were busy and they saw the research was not going anywhere."*

The interviewees commonly said that they did not receive any feedback from the industry practitioners on their research products after the team reported out. Interviewee A said *"we made presentations of the variety of different venues, and it's been very well received"*. However, when asked about academic journal paper publication, he answered that the PIs had not published the research results in academic journals.

The Annual Conference Survey is conducted every year at conference to assess how attendees perceive presentation performance and value. This survey analysis provides attendees rating on each presentation at a conference including research team presentation. The survey analysis of the year that this team reported out indicates that this team ranked the lowest out of five research teams reporting out. This rank was based on the combined rating of the plenary session presentation and implementation session presentation. If the ratings of the two presentations were analyzed separately, this team ranked 4th in the plenary session presentation and ranked 5th in the implementation session presentation. This team delivered the research summary and the research report. The research summary of this team was among the top 5 most downloaded CII products of the year when the team reported out.

Appendix M10

Individual Case Description Report

Special Case: S1

Table of Contents

List of Tables

1. Introduction

1.1 CASE INFORMATION

The general information of S2 is summarized in Table M10-1.

Case Category	Special		
Project	Project period	Total 2 years	
	kickoff date	Early November	
Industry Chairs	Number of chairs	2 co-chairs	
	Change in chairs	No	
	Previous CII experience	Yes	
Principal Investigators (PIs)	Number of PIs	2 PIs	
	Change in PIs	No	
	Previous CII experience	No (lead-PI) Yes (co-PI)	
Team members	Number of members (excl. academics)	Kickoff: 19	Owner: 10, Contractor: 9
		Report out: 19	Owner: 10, Contractor: 9
	Number of industry members with previous CII research team experience (excl. chairs)	3	
Research Methodology	Research Method	Case studies	
		Quantitative + Qualitative	
	Validation Process	Tool validation	
Products	Products published	Research Summary: 1	Published on schedule
		Implementation Resource: 1	Published on schedule
		Research Report: 1	

Table M10-1: Case Information

1.2 DATA SOURCES

The main data source for this case study was individual interviews with four members of this team. Other data sources to support and/or supplement the interviews included CII Post Research Team Survey (Post RT Survey) responses of this team and CII documents and archival records. The detailed data sources and their availability for analysis are summarized in Table M10-2. All the available sources in Table M10-2were analyzed to investigate the case from multiple perspectives. Words, phrases, and sentences in italic font with quotation marks in this case description indicate direct quotes from the interviews or comments of the Post RT Survey respondents.

Data Type	Data Source		Available and used for analysis
Interview	4 interviews	2 academics	Yes
		2 industry team members	Yes
Documentation	Team documents (retrieved from CII SharePoint)	Research Topic Statement	Yes
		Proposal	Yes
		Charter	Yes
		Meeting agenda	Yes
		Meeting minutes	Yes (7 meeting minutes)
		Interim Reports	Yes (two reports)
		Team roster	Yes
	Research products	Research Summary	Yes
		Implementation Resource	Yes
		Research Report	Yes
Archival Records	CII surveys	CII Post Research Team Survey	Yes
		Annual Conference Evaluation Survey	Yes
	CII records	CII product usage - Hardcopy sales and e-copy downloads numbers	Yes

Table M10-2: Case Information

1.2.1 Interviews

For this team, 4 team members were interviewed; 2 were academic researchers and 2 were industry team members. Only one of the 4 interviewees, the co-PI interviewee, had participated on a prior CII research team. Each interview was conducted on a one-to-

one basis at a different time and place. Interview durations were approximately 2 hours. Dialogues of three interviews were digitally voice-recorded upon the written consent of the interviewees, and one interview was documented by interviewer notes only because the interviewee declined to be voice-recorded.

1.2.2 CII Post Research Team Survey (Post RT Survey)

A total of 9 industry team members of this team responded to the CII Post RT Survey. The Post RT Survey is sent by CII to every CII research team member after the team reported out at a CII Annual Conference. The survey analysis considered the ratings and comments that the respondents provided in a narrative form. Since less than half of the team members responded, any statistics on the respondents' ratings based on a five-point scale were only regarded as referential.

1.2.3 Other data sources

Other data sources collected and reviewed for this case were team documents and CII archival records relevant to this case. The team documents included the research topic statement provided to this team by CII, the proposal submitted by the PIs to CII, the team charter, meeting minutes, team rosters, interim reports submitted to CII by the team, and the research products that the team delivered (i.e., research summary, implementation resource and research report). The CII archival records included CII Post RT Survey responses, CII Annual Conference Evaluation Survey ratings, and hardcopy sales and e-copy downloads numbers of the research products of this team.

2. Case Analysis

2.1 CASE OVERVIEW

The team started with a kickoff meeting in early November with a target report out date in 21 months. The research topic statement was provided to the team with the essential question and expected potential deliverables. In the kickoff meeting, the team drafted a team charter which included the research background, the definition of the topic, the research purpose and objectives, the limitations, the specific deliverables and team norms.

This team did not experience any leadership changes. The 2 co-chairs and the 2 PIs stayed until the end of the research. Both co-chairs had prior CII research team experience serving as a team member. One of them had participated on 2 CII research teams. The co-PI participated on one CII research team as a PI in prior whereas the lead PI did not participated on any previous CII research team as a PI. The lead PI was a

junior faculty member when this research team started, and the co-PI, who was a senior and experienced faculty member, was *"added in the proposal phase as a request from CII"* because CII *"wanted previous CII research team experience"*, as the co-PI interviewee said. Both PIs had a civil engineering background specializing in construction management.

The initial members included 19 industry members, the 2 PIs, and 1 graduate research assistant. The attendee list for the kickoff meeting noted 10 owner members and 9 contractor members. Of these 19 members, 12 were in manager or director positions except a couple of members who were in a senior executive level. The final team members, listed in the research summary, were 20 excluding the 2 PIs and 1 graduate research assistant. This number is inconsistent with that of team roster as of 2 months before the team reported out. This last roster of the team listed 19 industry members. Among these 19 members, one member, who is not listed in the research summary, never attended team meetings. Another member, who attended 5 face-to-face meetings either in person or call-in and is listed in the research summary, is not included in this roster. On the other hand, one member who never attended team meetings is listed in the research summary while he is not listed on the roster.

Of a total of 8 face-to-face meetings, the minutes of 7 face-to-face meetings were available for analysis. Based on the attendees listed in each of the meeting minutes, the average number of face-to-face meeting attendees was 11 with an average attendance of 55%. The team had a face-to-face meeting every 8 weeks starting from the kickoff meeting to February of the last year. Three industry team members excluding the 2 co-chairs had previous CII research team experience. Of these 3 members with prior CII research team experience, one member did not participate in the team meetings at all.

2.2 STRENGTHS AND WEAKNESSES

Table M10-3 includes key responses of the interviewees about strengths, weaknesses and/or challenges, and unique aspects of this team. A couple of the interviewees considered experienced team members as a strength. Besides this, each of the 4 interviewees had slightly different perceptions. Interviewee A viewed "*strong team spirit*" and "*strong participation"* as strengths. This interviewee also thought that the effort to stick to the schedule was helpful as presented below.

> *"We were able to agree quickly what we were going to do as a team……we were able to stick to the schedule that we had prepared so we were always on schedule. I think it helped the industry guys on the team in order to stay engaged and to keep that good team……interim accomplishment makes that much easier to pursue the next challenge on the team."*

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Academic – co-PI)	Interviewee C (Industry member)	Interviewee D (Industry member)
Strengths	• The graduate research assistant. • Good team dynamics. Strong team spirit. Strong participation. • Agreed quickly what we were going to do. Stuck to the schedule that we had prepared.	• Team makeup – owner and contractors. • Methodology – data collection from all of our team members was helpful. • Didn't encounter much disconnect between the original proposal and team expectations.	• The charter – helped alignment and building consensus. Reviewed the charter every meeting. • Developed common definitions and terms. • We set the realistic vs. sky objectives and goals and minimum – optimum expectations.	• Team members - experience in the topic. • A lot of very passionate members and a couple of very good academics. They [PIs] orchestrate the ideas. • A bunch of professionals who were passionate about the subject.....very experienced and eager to share their experience.
Weaknesses /Challenges	• Could have had better participation • There were travel restrictions due to the economic situation.	• Getting data from outside the team. • Didn't get much data from non-CII members.	• Participation: not everybody made every meeting. • To make all the people listed on the roster provide input was a challenge.	• They [members] traveled a lot…. very difficult to have a big presence [attendance] at the meetings. • We had two co-chairs couldn't participate much due to travels.
Uniqueness	• The tool - A balance between specificity and ease of use. • Two-tiered case studies.	• A lot of data came from the team members. • Looked at other CII studies and tools. • Creating a tool in the early stages of data collection was helpful.	• We used a mind mapping tool.	

Table M10-3: Strengths and Weaknesses – Interviews

Interviewee C made an interesting comment when he was talking about the team's strengths, which could be considered as a unique aspect of this team. This interviewee said that the team had two levels, high level and low level, for their research activities. According to the interviewee, the team set the *"realistic versus sky objectives* and goals", and *"minimum versus optimum expectations"*, and the team *established "minimum and maximum levels for every activity"* as well.

A weakness or challenge commonly perceived by the interviewees was participation. The team members had *"a lot of travel restrictions"* due to the economic situation at the time of research, and, moreover, the members *"traveled a lot"* for their work purposes, which *"made it very difficult to have a big presence* [attendance] *at the meetings."* Interviewee C particularly mentioned that it was a challenge to have input from all the team members.

Interviewee B, the co-PI, regarded collecting data beyond the team member companies as a challenge. This interviewee thought that the CII process had both benefits and challenges in terms of representativeness of data from the research methodology perspective.

> *"I think the benefit of the process that CII has in place is to capture the audience of the team members…… That is helpful in being able to collect that* [team member companies] *data. I think it does carry an inherent bias though because you have team members who are very interested in that topic, who are providing all the data, so it is not necessarily a representative subset, sampling out of CII membership or certainly not of the industry at large……I think if you look at a broader impact of that, there are real good pluses to it, but there are methodology challenges depending upon what sample you want to represent with those results."*

Interviewee D thought that there was a participation issue with the two co-chairs of this team. He consistently claimed throughout the interview that the two co-chairs *"couldn't participate much due to travels"* and were *"not visible"*. However, the attendee lists of seven face-to-face meeting minutes show that the owner co-chair attended six meetings in-person and the contractor co-chair attended four meetings in-person. The discrepancy between this interviewee's recollection and actual meeting attendance of the two co-chairs may be due to the fact that this interviewee participated in the face-to-face meetings mostly by call-in (four out of five meetings where he attended). The other three interviewees did not comment on any problems in regard to the chair participation.

When Interviewees A, B, and C were asked about unique aspects or innovative approaches of this team, each of them responded differently. Interviewee A thought that their tool and case study approach were unique. Interviewee B considered team member participation in data collection and developing a tool in early phases as unique. Interviewee C perceived a specific technique that the team used to facilitate team brainstorming as a unique or innovative aspect of this team.

Interviewee A said that the tool that the team developed was a *"good balance between specificity and ease of use"* which means that *"the tool wasn't set up to get just a general response of how you feel about something"* while avoiding being *"too specific to be too difficult to use."* Another aspect that this interviewee thought innovative was their case study approach. He described it as *"two-tiered case studies"*, one was more general and the other was more specific based on the findings from the more general one. According to the research, the more general case studies were conducted by the academic researchers, and the more specific case studies were conducted by all team members.

Interviewee B pointed out three aspects that he thought might be unique. The first one was to have each team member do *"their own case study"*. The second one was to investigate previous CII research studies and tools that have been successful. The third unique aspect was to create the *"implementation tool in the early stages of data collection"* so that the team was able to use the prototype tool *"to go out and collect more data"*.

One unique aspects that Interviewee C perceived was the use of *"a mind mapping tool to organize thoughts and sub-thoughts"* of the members. He said that the *"mind mapping tool"* helped the thought process and categorization of ideas. He recollected that the use of this tool was recommended by Interviewee B. About a month after this interview, the interviewer had the interview with Interviewee B, and asked him about the use of this *"mind mapping tool"*. Interviewee B said that the teams used this tool for *"a lot of things"*. The PIs used that tool *"to be able to categorize data and content analysis."* He also commented that this tool is a *"fast way to document and organize findings and present that back to the team"*.

2.3 RESEARCH METHODOLOGY

Key comments from the interviewees in regard to research methodology are listed in Table M10-4.

2.3.1 Scoping

According to Interviewee A, the team did *"alignment and chartering"* during the first three months along with the literature review. Interviewee C also said that the team developed the charter and established common definitions and terms during the first and second meetings. Interviewee D described this initial phase *"until figuring out what to do and what to produce"* as *"fun"* because members could learn from each other's experience.

Both academic interviewees perceived that the team quickly reached alignment around the research scope. Interviewee A said that they were able to agree quickly on what they would do as a team. Interviewee B also noted that alignment of the team was *"quite fast"* and *"very quickly"* the team *"came up with some common goals."* When the interviewees were asked about factors in such quick alignment, Interviewee B answered that alignment between the two PIs before the first team meeting was helpful, while Interviewee A regarded *"sticking the schedule"* as a contributor to fast alignment.

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Academic – co-PI)	Interviewee C (Industry member)	Interviewee D (Industry member)
Alignment around the Scope	• Agree quickly what we were going to do. • We stuck to the schedule.	• Quite fast. • [PIs] spent some time to make sure that we were on the same page.		• The team got a broad statement and it was up to the team to focus on what the scope was.
Scoping Phase	• Three months.		• 1st ~ 2nd meeting	• The process was getting to learn from another.
Scope Change	• The scope was high level, and didn't change.	• Didn't deviate much from the original proposal.		
Industry Member Background Study	• Industry literature review. • Presentations were made at this meeting.	• We had the team document the history and level of [the topic] of their companies.	• We had individual homework [topic related]. • Current CII research and other knowledge were presented in the meetings.	• Collected actual practices and approaches in their companies. • Presented the experience. • Looked at a lot of publications.

Table M10-4: Research Methodology – Interviews

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Academic – co-PI)	Interviewee C (Industry member)	Interviewee D (Industry member)
Industry Member Background Study	• Industry literature review. • Presentations were made at this meeting.	• We had the team document the history and level of [the topic] of their companies.	• We had individual homework [topic related]. • Current CII research and other knowledge were presented in the meetings.	• Collected actual practices and approaches in their companies. • Presented the experience. • Looked at a lot of publications.
Data Collection	• Three main components			• Most of the data were collected from the CII firms.
Validation	• Tool – external validity checks, face validity checks, and functionality checks	• Statistical validation was not really applicable.		
Data Collection - Industry Roles	• Presented the cases of their companies. • Some did interviews with people within their companies. • All of the validation was done with industry.	• Initially case studies of their own companies. • Leveraged our own team member companies.		• We answered the questionnaire internally • Developed a tool and tested it with our team member companies.

Table M10-4, continued.

> *"I think one of the things that helped us was,* [PIs] *spent some time to make sure that we were on the same page as far as what we envisioned was good methodology and presented that to our team."* – Interviewee B

> *"But we stuck to the schedule even though the schedule, when we originally conceptualized, we didn't know what we were going to really be doing in six months out. I think that was what helped get alignment quickly to get a plan down."* – Interviewee A

One thing which both academic interviewees commonly noted was that the team did not have a clear picture of a tool as one of the research deliverables. Interviewee A said that the team did not know *"what the end product would be"* during the first three months, and it was *"eight or nine months"* after the kickoff meeting when the team *"had a sketchy level of the tool"*. However, this interviewee emphasized that the team did *"know the road to get to the answer"* during the scoping phase. Interviewee B also said *"we did not have a solution at that time* [scoping phase]*, but* [had] *at least common goals and objectives as well as the charter."* This is consistent with the comment made by Interviewee C, one of the two industry member interviewees, that *"the team got a sense of tool format halfway of the process."*

One aspect about this scoping phase was that the two academic interviewees had different views when they asked if the team members changed or added any new ideas to the proposal that the PIs had submitted to CII. Interviewee A perceived that the proposal changed incorporating input from the industry members, whereas Interviewee B recollected that the team did not deviated much from the proposal, which he considered as a plus to team alignment.

> *"Did it change from what we had intended after interacting with industry people? For sure. It looks pretty different. We ended up going beyond what we planned to do."* – Interviewee A

> *"It* [alignment] *was pretty fast. We didn't deviate much from the original proposal, and I think that's what helped because we had already had it outlined in the proposal. It was pretty consistent."* – Interviewee B

To check this discrepancy between the two academic interviewees' perceptions, the original proposal and those of the team charter were compared item by item. The research purpose was stated identically in both the proposal and the team charter. For the research objectives, the team charter added a couple of more objectives to those of the original proposal. The research report stated the research purpose and objectives same as the team charter except that the research report specified the form of the tool.

The research approach and methods described in the original proposal were different from those stated in the research report. It could be possible that the research purpose and objectives did not change much from those of the original proposal, whereas the research methods and approaches deviated from those specified in the original proposal.

2.3.2 Team background studies

One research activity that the industry team members did during the initial phase of the research was the study of research background including literature. First, the industry members independently conducted cases studies of their own company practices regarding the research topic. Second, some of the team members reviewed relevant CII research studies and made presentations to the entire team.

According to the kickoff meeting minutes, *"all team members agreed"* to study their own company practices and, in the next meeting, each of the members planned to make a *"5-10 minute presentation"*. The review of literature was also assigned to seven team members including two PIs and the graduate research assistant in this kickoff meeting. Each of them made *"5-10 minute presentation"* in the next meeting. The minutes of the second face-to-face meeting noted that 11 industry team members presented their company case studies, and seven team members including the academics also made presentations on the literature review.

Interviewee A mentioned about two key benefits of industry team members doing background studies. Those benefits were; first, a better understanding of previous work relevant to their research, and, second, early engagement of the industry members.

> "*The key benefit of doing this* [industry members involvement in background studies] *was very quickly engaging the team member into the research process……I think the importance of the literature review was, well, first and foremost, that we understand what has been done before, and then each member brings something to the table for that discussion. Secondary, which is very important for other reasons, team dynamic and this sort of things, it bring people into the research process right away."*

Interviewee D also made a similar comment that the team became aware of the issues through literature review.

> "*After the literature review, we were cognizant of the issues.* [The purpose of this] *literature review is to know what is out there. So, we were aware of the issues, and we discussed what we would do about it and whether a company was ready to address that particular issue."*

2.3.3 Data collection and analysis

The team started collecting data after the second face-to-face meeting. Interviewee A said that the team was "*working on the case studies, both tiers of case studies"* during the second three-month period because the team was *"already discussing at the end of the first three months, the data collection plan"*. In the second face-to-face meeting, which was two months after the kickoff meeting, the PIs brought the data collection protocol for the team to review, which was

noted in the meeting minutes. This protocol was designed for the first set of cases studies, the *"more general"* case studies described by Interviewee A.

The academic group, the two PIs and the graduate research assistant, conducted the first case studies with the modified data collection protocol and reported the results to the team in the third face-to-face meeting, which was two month after the second face-to-face meeting. The minutes of the third face-to-face meeting noted that the *"team members brainstormed"* the case study results. One action item at the end of this meeting was to develop a survey for the second set of case studies. The industry members were grouped into seven sub-teams, and each sub-team was assigned a task to develop each section of the survey, which was also stated in the first interim report submitted to CII.

Interviewee D said, *"all of the data were collected by the industry people"*, and *"most of the data were collected from the CII firms"*. According to this interviewee, the PIs prepared *"a package"* for data collection, and the industry team members collected data from their own companies with that package.

> *"I asked people in my company with that package* [to do the survey], *solicit feedback and sent them back to the PIs."*

Both academic interviewees also mentioned that the industry members participated in data collection by conducting case studies of their own companies, and some of the industry members interviewed people in their companies.

> *"So each brought they interviewed people within their company and came back with their company's case. That was* [industry members'] *assignment."* – Interviewee A

> *"We had them* [the industry members] *go interview some people who had been around the company for some time try to get some historical data."* – Interviewee B

This second set of case studies conducted was *"engineering and construction industry case studies"*, as stated in the research summary. This case study effort was *"more specific"* and was based on the first three *"more general"* case studies done by the academic researchers. Interviewee B noted some benefits and potential pitfalls of industry members collecting data as presented below.

> *"So we really leveraged our own project team member companies to do those historical analyses because it was a little more time consuming. ……Something that a regular company probably, we probably would have very low success rating getting anyone to do that. So, we used our team members to go back and do those historical analyses.……There are challenges because you have issues of accuracy, consistency, and other things…. If you have one person collecting data or two people collecting data, it is pretty easy to manage*

consistency issues. If you have everyone in your team collect data, especially if it is not a well-defined methodology, you get some really mixed results."

Once the team developed their tool, the tool was validated through a team member company. The second interim report stated that the team *"tested the tool on a RT member company"* as a pilot test. After the team *"adjusted"* the tool *"based on the feedback"* from the team, each member tested the tool again at their companies. In addition, the team collected data at the CII BOA meeting to *"further validate and to calibrate the tool."* Interviewee D also mentioned that they *"developed a tool and tested it with the team member companies."* Interviewee A said that the team *"did external validity checks, face validity checks, and functionality checks on the tool."*

This series of processes was for tool validation rather than validation of data collected and analyzed. Interviewee B noted that validation of data was not applicable since statistical validation method did not fit the purpose as quoted below.

"Statistical validation was not really applicable because we were not really looking at the statistical side……I would not say that the data were statistically validated independently. It would be incredibly difficult.……We did some by collecting multiple data points from a same company. That gave some assurance that people consistently answered some of our questions."

Table M10-5 shows the Post RT Survey responses of this team related to data collection. A total of 8 members responded the three questions shown in table. No respondents answered 'Neutral', 'Disagree' or 'Strongly Disagree', which indicates that the survey respondents were satisfied with the data collection efforts.

Survey Question	Responses	
	Strongly Agree	Agree
The team had an appropriate and well organized data collection plan.	4	4
The quality of data collected and overall research met my expectations.	3	5
The data collection plan was well executed.	4	4

Table M10-5: Data Collection – Post RT Survey Responses

2.4 TEAM DYNAMICS

2.4.1 Team participation and commitment

Key comments from the interviewees in regard to team participation and commitment are listed in Table M10-6.

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Academic – co-PI)	Interviewee C (Industry member)	Interviewee D (Industry member)
Team Composition	• Good age distribution. • Status ranges VP to engineers.	• Diversity in age. • From smaller to larger companies.		• All of these guys were in the [topic] positions.
Team Diversity	• Have to find a balance between diversity [in opinions] and when to decide.	• Diversity in company experiences is really valuable. • I think there are pluses and minuses.		
Team Attrition		• Very little attrition.		• Toward the end, we didn't have a lot of people to break out.
Meeting Attendance	• 13 of 20 attended more than half of F2F meetings. • Ten people attended 70% of the meetings or more.	• A lot of people came to the team meetings and a lot attended remotely.	• A great challenge to meeting attendance since they did travel abroad a lot.	

Table M10-6: Team Participation and Commitment – Interviews

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Academic – co-PI)	Interviewee C (Industry member)	Interviewee D (Industry member)
Core Group	• 12 people	• I don't recall a specific number. These core people did more work than others.		• Handful of people who really pushed everything to the end.
Subgroups	• Subgroups worked independently during the last six months. • Alignment check is necessary. • Very effective.	• Last 6~8 months. • Three groups - no alignment issues among subgroups. • It helps get people deliver products.	• The subgroup members understood expectations. They were committed because they didn't want to let down friends.	• Face-to-face meetings - breakout sessions. • When you have a smaller group, you can do much more productive things.
Participation & Commitment		• Very good participation.	• People involved were involved. A few never participated.	• Maybe 60% of those people were actively involved. That means they came to more than two or three meetings.
Factors for Participation & Commitment	• Rewarding both in terms of the work and having some fun, you encourage more participation.	• They saw the value coming to the meetings. • We always tried to find fun places for the team meetings.	• We had team meetings where there were good events and good weathers. • Chairs and PIs kept the team moving.	• We really wanted to do something making sense to the industry. • Try to make meetings appealing.

Table M10-6, continued.

2.4.1.1 Team composition and diversity

Interviewee A said that the team had *"good age distribution"*. Interviewee B also said that the team was diverse in age adding that *"one strong contributor was quite young."* Both academic interviewees regarded diversity as *"important", "very helpful"* and "*really valuable"*.

When asked about the impact of diversity on team performance, both academic interviewees answered that diversity was good and important but not in every case. Interviewee A thought that research had to find a balance between when to allow diversity in opinions and when to make decision. Interviewee B perceived that diversity might not be best when producing deliverables.

> *"If there are such diverse opinions, the team can actually break down and just be discussing every possible change and option. So, you have to find a balance. You want to capture that diversity of viewpoints and you also need to decide when it is time to take a vote or if there's consensus. …… You might think you have to capture everybody's point of view or people won't be happy. But there are also people in the room who, if you allow this to go on for too long then you start lose your credibility. You also have to know when to shut it down and move forward."* – Interviewee A

> *"Diversity in company experiences is really valuable. In general, diversity in member experience is beneficial. Diversity is good in putting together innovative and new ideas, sometimes. When you start putting things together and produce something, I am not sure diversity is* [always] *necessarily the best. That can detract getting things done sometimes. I think there are pluses and minuses. The bottom line is getting a project done."* – Interviewee B

2.4.1.2 Team attrition and meeting attendance

In regard to team attrition, Interviewee B said that the team had *"very little attrition"*. The first interim report stated that one member *"has not participated in any meetings and has not replied to and research team communications"* since the kickoff meeting. This could be the member who was mentioned by Interviewee B in his comment that "*one moved to other company, which was kind of unavoidable."*

Interviewee A said that *"13 of 20 attended more than half of face-to-face meetings"*. He added that the team "*ended up with ten of people* [half of the team] *that attended 70% of the meetings or more"*. Interviewee C also commented that "*depending on job work load and availability"*, the team had *"70~80% of consistent* [team meeting] *attendees"*. Interviewee B thought that team participation was very good considering the economic situation at the time of the research.

Seven minutes of total 8 face-to-face meetings and one teleconference meeting minutes were available for analysis. The team had teleconference meetings *"as needed basis"* and meetings minutes of the other teleconference meetings were not available for analysis. According to seven face-to-face meeting minutes which were analyzed, eleven out of total 19 industry team members attended, either in-person or call-in, more than three meetings. The number of industry members who attended more than four meetings was nine, which is 47% of the total team members. The average number of attendees of those 7 face-to-face meetings is 11 with 55% of attendance.

2.4.1.3 Core group

Interviewee D recollected that the team *"had a handful of people who really pushed everything to the end."* Interviewee A, the lead PI, said that the team had *"a core team of 12 who had really invested in the team"* which was *"a sizable core group"* and *"was very committed."* Interviewee A noted that the academics assigned the core group of people among sub-teams so that the core group of people played a key role in each sub-team.

> *"We distributed theses core people across various stub-teams. We wanted a few people on each sub-team. I wouldn't call out a specific contribution of the* [core] *team rather they were the driving force to get the various sub-team efforts to complete on time and with high quality."*

Interviewee B, the co-PI, confirmed that the team had a core group of people even though he did not recall a specific number of people in that core group. However, he mentioned that there were *"five to six people"* who did *"independent work that required significant time"*. This interviewee further provided his perspective regarding member participation as quoted below.

> *"I almost put it in three levels. There are a couple of people who may not show up. Some people showed up in vast majority of meetings, but may or may not have a lot of input. A couple of people with very good contributions. A couple of people who were really engaged and performed tasks."*

When asked about factors in commitment of the core group, Interviewee A listed three drivers. Those drivers were first, the feeling of being part of the team, second, support from their companies, and third, having social time at meetings.

> *"They* [core group] *felt like they were part of the team, so they didn't want to let other people down……Their companies are strong investors in CII, so they were supported. They were not told not to come to the meetings……One of the team members said "we have travel restrictions, but our company believes this is a strategic priority, so I can come." So, that helped……We worked very hard in the meetings, but then we always had nice time in the evenings together. So, I think at least a small part of it* [factor in commitment] *was looking for enjoying evening together after working hard."*

2.4.1.4 Subgroup approach

The first interim report and the minutes of the third face-to-face meeting noted that seven sub-teams were formed to develop survey questions. Each team had *"homework to come up with five to ten questions"*. In the fourth face-to-face meeting, the team *"broke into three smaller sub-teams to refine"* the survey questions as noted in the minutes.

Both academic interviewees recollected that the team broke up into subgroups during the last six months to draft the research summary and to prepare two presentation sessions at the Annual Conference. Interviewee B recalled that *"team meetings became sub-team meetings"* and sub-teams *"worked independently"*. Interviewee A perceived that the subgroup approach was *"very effective"*, although the team had *"some misalignment between subgroups"* due to lack of an *"alignment check"*. He added that he would now have an alignment period between subgroups for another CII research team, on which he was participating as a lead PI.

> *"Yes. It was very effective. We set it up so the industry subgroups worked independently and had independent meetings during the last six months. We had some misalignment between subgroups, plenary and implementation session sub-teams. We may have lost a little bit of time because there wasn't an alignment check for a period of a couple of months. ……*[For my] *current team, we are still going to operate that last six-month sub-teams. However, we will meet in a same place and have a common session for alignment."*

Interviewee B said *"since people have limited time, it's good to put a team on subtasks"* after *"core development"* of research. Unlike Interviewee A, Interviewee B recollected there were *"no alignment issues among subgroups"* since the team had a *"conceptual solution completed before"* the team broke up into subgroups and the subgroups *"still took the input from the whole group"*. He added that it was more like breaking up *"the deliverable tasks rather than research tasks"*. Both Interviewee B and Interviewee D also perceived a subgroup approach as effective, saying that it helped people produce some *"defined deliverables"* and *"a good way to divide and conquer major issues"*.

Regarding subgroup operation, Interviewees A, B, and C commonly mentioned that the two PIs and the graduate research assistant were spilt up into three sub-teams, which were the research summary development team, the plenary session team, and the implementation session team. This was consistent with the minutes of the sixth face-to-face meeting, which was approximately 10 months before their report out date. The minutes listed the members of each of three sub-teams. That list showed that each sub-team had at least one member from either co-chairs or academics. Interviewee C pointed out that the subgroup members understood expectations, and they were committed because *"they did not want to let down friends"*.

2.4.1.5 Factors in team participation and commitment

All of four interviewees commonly viewed having attractive and fun team meetings as a factor in member participation. The team arranged face-to-face meetings where *"there were good events and good weathers"*, and the team *"always tried to find fun places for the team meetings and to do something special"*. For example, Interviewee A recalled that the team met in New York City for St. Patrick Day and watched the parade together after the meeting. Interviewee A added that this team meeting arrangement was what he *"carried forward for my current CII research team"*, and he pointed out that his current team also has had *"very, very strong participation"*. He commented that since the CII research is a *"diversion from the real job"*, if it could be *"rewarding both in terms of work and fun"*, the team could be encouraged for *"more participation"*.

Other factors mentioned by the interviewees included the team members seeing the value of participating on the team, having the team members who had passion about the topic, and the friendship formed among the members. Interviewee B noted that the team members *"saw the value in coming to the meetings and learning"* since *"their job in their organizations was closely related to the topic"*.

> *"…… I don't know if to some degree they did, but I don't think it was just viewed as a service activity that they were doing just to give back to the industry. I think they saw the benefit when they got together of being able to learn from peers and other organizations."*

Interviewee C thought that people were committed because they did not want to disappoint friends (other team members). Interviewee B also made a similar comment that the lead PI (Interviewee A) made *"a lot of good friends"* in the team and the lead PI was *"able to leverage that."* Interviewee D described the team as *"a bunch of passionate people"*. He viewed *"those that drop off early"* as *"not passionate"* and *"those that stay for the long-run"* as *"committed."*

2.4.2 Leadership

Key comments from the interviewees and the Post RT Survey respondents in regard to team leadership are listed in Table M10-7 and Table M10-8, respectively.

2.4.2.1 Industry chairs and PIs

This team did not experience any leadership change in either academic side or industry side. This team had two co-chairs, each from owner side and contractor side, and one lead PI and one co-PI. The Post RT survey responses of this team for the questions about the PIs and co-chairs were positive without any negative responses including 'Neutral'.

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Academic – co-PI)	Interviewee C (Industry member)	Interviewee D (Industry member)
Leadership	• Mix of both, reasonably balanced	• It was much more academic-led than industry led.	• We had a good balance....practical feedback and a theoretical portion of the research.	• At least in the beginning, we didn't have strong leadership from the industry side. • More led and managed by academics.
Chairs	• Strong co-chairs who stuck to the schedule.	• They were more service-oriented and looking at what they could do.		
Expectations established by chairs	• In the Charter (written into the norms). • The team is counting on you. It wasn't written in the charter, but it was norms about team interactions.		• The chairs had three guidelines. 1) Work well together. 2) Have fun. 3) Accomplish the charter objectives and goals.	
Two Chairs	• Owner and contractor balance is important.	• To be honest, I don't think it does matter. • The chairs are helpful if they are actively engaged and they want to be very actively engaged to be willing to take a role of a chair.		• It is effective. It is a good representation. It gives an equal platform to both....address both.

Table M10-7: Team Leadership – Interviews

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Academic – co-PI)	Interviewee C (Industry member)	Interviewee D (Industry member)
PIs			• PIs – kept and made sure everybody was involved in discussions.	• Not necessarily because led by them (PIs), but because…...these guys (PIs) will do it, we kind of throwing things at you (PIs), you (PIs) put it together.
PI & co-PI	• We had personal interactions and relationships. • We did not explicitly separate tasks - did when we formed sub-teams.	• Very good. • Sometimes we separate tasks.		• The two PIs kept alignment. They did a great job.
Leadership Communication	• We did some [leader meeting].			
Leadership Roles & Responsibility	• The PIs prepared meeting agendas. Chairs kicked off every meeting and ran the show.	• Academics led the team meetings, prepared agendas, and took meeting notes.	• PIs made sure the flow and priority of discussions. • The chairs made sure we got everything we needed at the end of meetings.	• It [PIs' role] is a supporting role. It is important because it bring consistency.....The PIs are like consultants.

Table M10-7, continued.

Survey Question	Responses	Comments
The Principal Investigator(s) (team academic(s)) did a good job of structuring and facilitating this research.	• A total of 9 responses • 'Strongly Agree' – 9	• Definitively [the lead PI] and his students team did a great job to represented our thoughts in sustain way - simple and friendly use. Extremely dedicated. • [The lead PI] presented the schedule and milestones at the first meeting and kept us reminded of the schedule throughout the research period.
The Co-Chairs provided the expected leadership necessary for team success.	• A total of 9 responses • 'Strongly Agree' – 6 • 'Agree' – 3	• No comments provided.
The academic support (development of methodology, facilitation, data analyses, meeting support, etc.) was appropriate and met my expectations.	• A total of 8 responses • 'Strongly Agree' – 8	• The support from our academic members was GREAT .... especially in the development of the tool that we created!! • I learned new ways of methodology and data analyses. This was really interesting.

Table M10-8: Team Leadership – Post RT survey Responses

For the question 'The Principal Investigator(s) (team academic(s)) did a good job of structuring and facilitating this research', all nine responses of this question are 'Strongly Agree'. All of eight responses to the question 'The academic support (development of methodology, facilitation, data analyses, meeting support, etc.) was appropriate and met my expectations' are 'Strongly Agree' as well. In terms of co-chair leadership, six responded 'Strongly Agree' and three responded 'Agree' out of total nine responses to the question 'The Co-Chairs provided the expected leadership necessary for team success'.

The interviewees showed mixed responses in regard to leadership of this team. Interviewees A and C described that the leadership of the team was *"mix of both"* academics and industry and the team had a *"good balance"* between the academics and industry. Interviewee C said that *"industry provided practical feedback and review based on reality"* and *"academics provided a theoretical portion of the research"*. On the contrary, Interviewees B and D described their leadership as *"much more academic-led than industry-led"* and *"managed by academics"*. Interviewee B further clarified his opinion on leadership that research should be led by the academics as below.

> *"I am biased and I think it should be that way. If you let industry lead, you are in trouble. People want to look at all different things. The research methodology, research approach and research activities need to be from academics with the industry support."*

In regard to the leadership of the two co-chairs, both academic interviewees viewed it as *"nice blend and mix"* and *"complementary"*. Interviewee A said that the two chairs *"played a critical role"* in *"keeping the meetings and progress on schedule"*. When asked about the styles of the two co-chairs, Interviewee A answered that the two co-chairs were *"very different"*. According to his description, the contractor co-chair was *"a really good leader"* and *"really good at refocusing the team"*, for instance, the contractor co-chair would *"bring it* [the focus of the team] *back to the point when creativity of the team went too far"*. On the other hand, he recollected that the owner co-chair *"did a lot for team dynamics"* rather than *"pushing the schedule"* and *"kept people interested and participating"*. Interviewee B made a similar comment about the co-chairs. This interviewee said *"they* [the co-chairs] *did take a leadership role and try to make people engage and show up"*. He characterized the co-chairs as *"more service-oriented"* and *"looking at what they could support"* and *"not driving a specific agenda"*.

When it came to the academic leadership, Interviewee C said that the two PIs *"kept and made sure everybody was involved in discussions"*, and the interviewee thought that, in such a way, the two PIs *"promoted a safe environment for open discussions"*, and *"kept individuals from dominating a discussion"*. Interviewee D made an interesting comment about the academics leading the team. He thought the industry team members let the academics lead the team by relying on them as quoted below.

> *"…… That was the attitude of that team……Not necessarily because* [the team members were] *led by them, but because we kind of said, okay, these guys* [the PIs] *will do it, we were kind of throwing things at you* [the PIs], *you* [the PIs] *put it together."*

This interviewee additionally commented that another CII research team that he was on was more led by industry members, which he liked more.

2.4.2.2 Leadership roles and responsibilities

When the interviewees were asked about the roles and responsibilities of the chairs and PIs, all of the four interviewees perceived that the co-chairs and the PIs took different roles and responsibilities. Interviewee C described the different roles and responsibilities of the co-chairs and the PIs in a broader perspective. He recollected that *"the PIs led the team meetings"* and *"made sure the flow and priority of discussions"*. According to his expression, the PIs provided *"passive leadership"* by asking questions in discussions, whereas the co-chairs made sure that the team *"got everything needed at the end of the meetings"*. This interviewee then provided some specific roles that the co-chairs played for the team. First, the co-chairs, together with the industry group, *"checked the reality of PIs' content"*, second, the chairs *"kept the team on track"*, and third, the co-chairs *"kept the meeting stay focused and contacted people who were away so that they could keep involved"*. In addition to these roles, he also indicated that the co-chairs *"participated in discussions as everybody else"* as well.

Interviewee A said *"the chairs kicked off every meeting and ran the show"* while *"academics prepared meeting agendas"*. From his perspective, the academics (PIs) were *"set up like consultants for the team to help them out figure out answers"* since the academics knew *"how to find an answer"* and were *"driving the process and did behind the scenes work."* However, he said that he did not think the team clearly differentiated the roles and responsibilities of the chairs and the PIs up front. He added that, on his current CII research team, *"the roles were set up"* and *"re-divided"* when the team had the kickoff meeting.

Interviewee B said there were *"certainly different roles for different players."* The academics' roles and responsibilities included scheduling meetings, preparing agendas and presentations except industry presentations of their case studies, and leading the team meetings. He recalled that *"it* [the whole process] *was very academic"*. Interviewee D perceived the role of academics as a *"supporting role"* and *"important because it bring consistency"* to the research team. He described PIs as *"consultants"* who were doing consulting the industry.

When the interviewees were asked about their thoughts on having two co-chairs on a CII research team, one from the owner side and one from the contractor side, Interviewees A and D viewed it positively. Interviewee A thought it as *"one of the things that make the CII process successful"* and *"critical"*. He emphasized that this approach was *"really important for owner and contractor balance"*. In addition, Interviewee A mentioned that *"developing a mutual respect"* was more important than having two co-chairs from each of the owner side and the contractor side to have a *"fully participating team"*. Interviewee D also perceived that having two co-chairs was effective.

> *"It is effective. It is a good representation. It gives an equal platform to both owners and contractors. The fruit of the research will address both. The last thing you want is to have both co-chairs from one side."*

Interviewee B, the co-PI, had a different viewpoint on this issue. He did not think that having two co-chairs, one owner co-chair and one contractor co-chair, had significant importance. He said that it might matter from *"the perspective of communication of CII"*, but he really did not think it mattered. He thought that the more important thing was having chairs with willingness of playing a role of chair as presented below.

> "*My experience with two teams, the chairs are helpful if they are actively engaged and willing to take a role of a chair. But, I don't think it matters if they come from contractors or owners because we have very active other members* [from each side]*."*

This interviewee also commented that there would be a problem if chairs would drive the agenda of a team. He thought that it would be a challenge if chairs tried to drive an agenda apart from the team's collective decisions. He said that he did not *"encountered that problem"*.

> *"The major problem is if the chairs drive the agenda. It should be driven by the team from collective decisions not from any individual as a chair……Chairs are there to provide support. If someone is driving a particular agenda or particular direction that is not aligned with a collective desire of other members, it could certainly be a challenge. Everyone has their voice, and I don't think the chairs voices carry more weight than anybody else's'. Chairs can be more active, but I don't think it would really matter."*

When asked if there were any expectations established by the co-chairs, Interviewee D answered that the co-chairs had *"three guidelines"*, which were to *"work well together"*, to *"have fun" and* to *"accomplish the charter objectives and goals"*. Interviewee A said that the expectations of the co-chairs were specified in the team charter. He then emphasized that a more important thing was the way of the meetings run by the co-chairs presented as below.

> "[The co-chairs were clear about that] *'you* [the team members] *can't not attend the next meeting because you have to present something. The team is counting on you.'.....It wasn't written in the charter, but it was the norm about team interactions……once it becomes a norm then everyone can be a policeman and make sure that it happens that way."*

2.4.3 Team relationship and communications

Key comments from the interviewees and the Post RT Survey respondents in regard to team communications are listed in Table M10-9 and Table M10-10, respectively.

2.4.3.1 Conflicts

Interviewee D said that there were no conflicts in the team. He recalled that the two PIs kept alignment. Interviewee C said that the team had no major conflicts. He listed two reasons for that; one was that the *"baseline* [charter] *was clear and agreed by all members."* The other was that the team *"developed common definitions and vocabularies in the first and second meetings and time between those two meetings"*. This interviewee then recollected one conflict that happened among the team members, which was about the survey that the team conducted. According to his recollection, the PIs presented the survey in one meeting and asked the members to distribute within team member companies. The PIs wanted to send the survey out as soon as possible because they wanted to push collecting data, but the members pushed back. The interviewee said that the industry team members wanted clear questions because the industry team members did not want to distribute ambiguous questions in their companies. He said that the PIs re-prepared the questions, and the industry members brought the revised survey to their companies.

2.4.3.2 Team meetings

Based on the analysis of meeting minutes of this team, the team met face-to-face in every other month during the first year and then every 8 to 10 weeks during the second year. The sub-teams had separate meetings including both face-to-face and conference call meetings. During the last eight months, most team meetings were around the plenary session sub-team and the implementation session sub-team. The team utilized conference call meetings as well, even though it was less formal. Interviewee B said that the team had conference calls outside face-to-face meetings and between certain members, but he did not recall that the team did regular monthly conference calls. Interviewee C also mentioned that the PIs requested conference calls *"as needed if there was an issue paramount to have discussions"*. The CII SharePoint site for this team listed only two conference calls for the whole team, and only one of those two meetings had meeting minutes posted on the SharePoint. The other two meetings, shown on the SharePoint site, were sub-team conference call meetings.

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Academic – co-PI)	Interviewee C (Industry member)	Interviewee D (Industry member)
Conflicts			• No conflicts. 1) because baseline (charter) was clear and agreed by all members. 2) We developed common definitions and vocabularies (in early stages). 3) One conflict was about the survey.	No
Team Meetings		• I don't recall we did regular monthly conference calls.		
Social Activities	• Chose locations for not just the ease of getting there but also what else might be going on.	• All kinds of social activities are valuable.		
GRA	• GRA was willing to learn and understood the excel development.			
Team Operation & Management	• Assigned an industry member to take meeting minutes every meeting	• Very beneficial to have meetings frequently in the very beginning.	• During the meetings, an agenda was prepared for the next meeting. • Meeting notes were taken by a randomly picked member. • Reviewed the charter every meeting.	• PIs led the meetings.

Table M10-9: Team Communications – Interviews

Survey Question	Responses	Comments
The research team was properly aligned throughout the project.	• Total 9 responses • 'Strongly Agree' – 5 • 'Agree' – 4	• Well aligned, but the diversity of the group brought excellent views that challenged the value of the research product.
The research team got off to a good start.	• Total 8 responses • 'Strongly Agree' – 4 • 'Agree' – 4	• I missed the initial meeting but was sent the meeting notes and the 2nd meeting went on as preplanned. Each meeting following had an agenda prepared and we stayed with that agenda.
The research project plan and schedule were communicated and agreed to before significant work began.	• Total 8 responses • 'Strongly Agree' – 6 • 'Agree' – 2	No comments
What was the research team meeting frequency (both face-to-face and by phone/web?)		• Monthly in the beginning, switching to bi-monthly and then as needed. • Met face of face on a quarterly basis with telecoms in between. • Meeting frequency initially was monthly or two months (latest) (face to face and phone/web) during first year. • Every other month • Approximately 3-4 times per year in person and towards the end conference calls about once a month. • Quarterly face to face. • Meetings were about every 3 months.
The research team meeting frequency (phone, web, face-to-face) was appropriate and efficient.	• Total 8 responses • 'Strongly Agree' – 4 • 'Agree' – 4	No comments

Table M10-10: Team Communications – Post RT Survey Responses

The respondents of the Post RT Survey provided positive answers to the survey question 'The research team meeting frequency was appropriate and efficient'. Four out of total eight responses were 'Strongly Agree', and the rest four responses were 'Agree'. In regard to this meeting frequency and its effectiveness, Interviewee B provided a unique perspective. He thought that having a full team meeting when a project approached closer to the end was not necessary. He regarded a sub-team approach as more necessary for this period.

> *"I found it very beneficial to have meetings frequently in the very beginning, but once you have the core concept and solution put together and some initial data collected, I actually found it that not necessarily to have the whole team get together – that's when sub-teams are divided. Once everyone is aligned,* [there is] *not much need to put everyone in the same place."*

This interviewee also noted that economic downturn was one of external challenge, and *"a lot of CII companies were on restricted travel"*. However, he said that the team *"had a very aggressive approach probably more than"* he would have wanted. He pointed out that the team *"tried to get everybody every two months no matter what throughout the whole time period"*. He added that he was *"actually not convinced"* of the need to do that.

In the team meetings, the industry members took meeting minutes. Interviewee A, the lead PI, said that one of the industry members was assigned to take minutes every meeting, a note taker would send a draft to the lead PI, and the lead PI and the graduate research assistant edited the draft minutes. The edited version was then passed to the co-PI and two co-chairs. After the academics and the co-chairs *"was okay with that"*, the meeting minutes were distributed and posted on SharePoint. This interviewee explained that this approach was *"to encourage industry participation."* However, he admitted that *"it took time."* For that reason, he mentioned that the graduate research assistant should capture meeting minutes as with current CII research team that he is on since he thought the previous approach did *"not seem to have a lot of strategic value."*

2.5 PRODUCT DESIGN AND DEVELOPMENT

Key comments from the interviewees and the Post RT Survey responses in regard to research products are listed in Table M10-11 and Table M10-12, respectively. This team delivered three products – one research summary, one implementation resource, and one research report. The team submitted the draft research summary and implementation resource to the PRB on schedule, and the final research summary and implementation resource were published before the team reported out at the CII annual conference. Neither product is highly ranked. For example, among the top ten, in download numbers of the year when the team reported out.

Question Category	Interviewee A (Academic – Lead PI)	Interviewee B (Academic – co-PI)	Interviewee C (Industry member)	Interviewee D (Industry member)
Product Quality	• Easy to use. Graphically clean.	• I think we created a tool that is quite useful. • We used a more than adequate level of academic rigor.	• Useful tool. Perfect quality. It is dynamic and modifiable. I think it is huge value. • CII should be able to market tools.	• It is a nice tool, and it is interactive. It fits for the purpose what we wanted. • It is very user-friendly.
Key Considerations	• Easy-to-use. • Had to meet the objectives we set. • Does what we intended it to do. • Useful for the companies. Valuable CII tool.	• We wanted it to be guiding in nature. • Easy-to-use	• Target audience – who is going to be the end users? What level of personnel will use this? • Usability	• Something practical and useful to the industry…...something very practical otherwise it was not going to be used.
Feedback	• No opportunity to get some feedback from industry users.	• Within the team, good feedback. • We've published several papers which were positively received by the academia.		

Table M10-11: Product Design and Development – Interviews

Survey Question	Responses	Comments
The research project deliverables (Research Summary and Implementation Resource, if appropriate) were most suited to improve performance of CII member companies.	• Total 9 responses • 'Strongly Agree' – 8 • 'Agree' – 1	• No comments provided.
The topic and research conducted were consistent with what I initially expected.	• Total 8 responses • 'Strongly Agree' – 6 • 'Agree' – 3	• It allow corporations that wants to expand to have tools that can help them to measure progress and identify challenges in there process. • Several colleagues have been active in CII research teams. In conversations prior to signing up I was told about away meetings and homework. This was what I expected.

Table M10-12: Product Design and Development – Post RT Survey Response

All the interviewees were satisfied with the quality of products that the team produced. The interviewees perceived the tool that the team developed *as "useful", "interactive", "dynamic and modifiable"* and *"very user-friendly"*. Interviewee C said that he thought the tool was of *"huge value*" and CII needed to *"be able to market tools"* that CII research teams produced. Interviewee D mentioned that the tool fit *"the purpose"* what the team wanted. Interviewee B said that they *"used more than the adequate level of academic rigor"* even though their research was *"applied research"*.

The respondents of Post CII RT Survey of this team responded very positively as well to the question 'The research project deliverables (Research Summary and Implementation Resource, if appropriate) were most suited to improve performance of CII member companies'. Eight out of 9 responses to this question were 'Strongly Agree' and the remaining one response is 'Agree'.

Key considerations in developing the tool mentioned by the interviewees include *"easy-to-use", "meeting the objectives", "practicality", "valuable tool", "target audience"* and *"usability"*. Interviewee A mentioned that the team did not have an opportunity for feedback from industry users. Interviewee B said that the two PIs had published several academic papers and feedback from the academia was positive.

Appendix M11

Individual Case Description Report

Special Case: S2

Table of Contents

List of Tables

1. Introduction

1.1 CASE INFORMATION

Table M11-1 summarizes the overall information of the case S2.

Case Category	Special		
Project	Project period	More than 2 years	
	kickoff date	Late October	
Industry Chairs	Number of chairs	2 co-chairs	
	Change in chairs	Yes	Owner co-chair: 2 times
	Previous CII experience	Yes	Owner – 1, Contractor – 2
Principal Investigators (PIs)	Number of PIs	3 PIs	
	Change in PIs	No	
	Previous CII experience	Yes	
Team members	Number of members (excl. academics)	Kickoff: 22	Owner: 9, Contractor: 13
		Reporting out: 15	Owner: 5, Contractor: 10
	Number of members with previous CII research team experience (excl. chairs)	7	
Research Methodology	Research Method		
	Validation Process	Tool validation	
Products	Products published	Research Summary: 4	
		Implementation Resource: 5	
		Research Report: 3	

Table M11-1: Case Information

1.2 DATA SOURCES

The main data source for this case study was individual interviews with 3 academics and 4 industry members of this team. Other data sources to support and/or supplement the interviews included CII documents and archival records. The detailed data sources and their availability for analysis are summarized in Table M11-2. All the available sources in Table M11-2 were analyzed to investigate the case from multiple perspectives. Words, phrases, and sentences in italic font with quotation marks in this case description indicate direct quotes from the interviews or comments of the Post RT Survey respondents.

Data Type	Data Source		Available and used for analysis
Interview	7 interviews	3 academics	
		4 industry team members	
Documentation	Team documents (retrieved from CII SharePoint)	Research Topic Statement	Yes
		Proposal	Yes
		Charter	Yes
		Meeting agenda	No
		Meeting minutes	8 face-to-face meeting minutes
		Interim Reports	Yes (8 reports)
		Team roster	Yes
	Research products	Research Summary	Yes
		Implementation Resource	Yes
		Research Report	Yes
Archival Records	CII surveys	CII Post Research Team Survey	No
		Annual Conference Evaluation Survey	Yes
	CII records	CII product usage - Hardcopy sales and e-copy downloads numbers	Yes

Table M11-2: Data Sources

1.2.1 Interviews

For this team, a total of 7 team members were interviewed; 3 Principal Investigators (PIs) and 4 industry members. One of the 4 industry team members was the owner co-chair. All of the academic interviewees had prior CII research experience while only the owner co-chair had prior CII research team experience among the industry interviewees. Each interview was conducted on a one-to-one basis at a different time and place. Interview durations ranged from 1 hour to 2 hours depending on interviewees' time availability. Dialogues of all 7 interviews were digitally voice-recorded upon the written consent of the interviewees.

1.2.2 CII Post Research Team Survey (Post RT Survey)

The CII Post Research Team Survey data were not available for this team.

1.2.3 Other Data Sources

Other data sources collected and reviewed for this case were team documents and CII archival records relevant to this case. The team documents included the research topic statement provided to this team by CII, the proposal submitted by the PIs to CII, the team charter, meeting minutes, team rosters, interim reports submitted to CII by the team, and the research products that the team delivered (i.e., research summary, implementation resource and research report). The CII archival records included CII Annual Conference Evaluation Survey ratings, and hardcopy sales and e-copy downloads numbers of the research products of this team.

2. Case Analysis

2.1 CASE OVERVIEW

The team started with a kickoff meeting in late-October. The research topic statement was provided to the team with essential questions and potential deliverables. In the kickoff meeting, the team drafted a team charter which included background, definition of the topic, purpose, objectives, limitations, specific deliverables and norms.

This team experienced industry leadership changes. The owner co-chair changed two times while the contractor co-chair stayed unchanged. The co-chairs including two new owner co-chairs had previous CII research team experience. The 3 PIs also had prior CII research experience. They had participated as a PI on more than one CII research team. All PIs had civil engineering background specializing in construction management, and they were from different universities.

The initial members of this team were 22 industry members plus 3 PIs and 2 graduate research assistants according to the roster included in the kickoff meeting materials prepared for this team. There were nine owner members and 13 contractor members from these initial 22 members. More than the half of the initial members was in a director or manager position within their company. There was only one vice president, and several members were engineers or supervisors. The industry team members were reduced to15 at the time of the interview when the team was at its fifth year of the research, and there were five owner members were and ten contractor members. From these 15 members, 11 members were managers or directors, three were vice presidents, and the one member was a specialist engineer.

2.2 STRENGTHS AND WEAKNESSES

Table M11-3 shows key comments of the interviewees to the question asking about strengths, weaknesses and/or challenges, and unique aspects of this team. The common strength noted by both academic and industry interviewees was industry members of the team. The interviewees mentioned that a *"core group"* of industry team members was one of the strong sides of the team. Interviewee A commented that the team had a *"good core group of industry members"* with *"quite huge commitment"*. Interviewee D mentioned that *"the core group"* has been *"on the same page from day one"* and they had *"a common goal and expectations"* for the research. Interviewee B said that the team had *"very good participation from the industry members"*, emphasizing that the team *"managed to stay strong through renewal"* since the team is a long-term project. In the same context, Interviewee E regarded the internal teamwork as strength, and Interviewee F commented about the experience of the industry members and their "*interest in the results and the findings"*.

Other strength mentioned by some of the interviewees was the academic side of the team. Interviewees A and B viewed that having three academics from different universities was one of the strengths. Interviewee A mentioned that having *"different perspectives to a project is certainly a strong point"*. Interviewee B said that *"complementary personalities and styles and yet complete trust"* of the academics *"really helped the research worthwhile and good quality as a result"*. Interviewee D, the owner co-chair interviewee, said that the academic that they had on the team were *"very strong"*.

Question Category	Interviewee A (Academic – PI)	Interviewee B (Academic – PI)	Interviewee C (Academic – PI)
Strengths	• Multi-universities • Good core group of industry members • Cycle approach • Access to company data • Tool validation	• Three academics - very complementary personalities and styles • Very good participation • Six year program • Not constrained by the lifecycle of a typical research team. • A nice balance between good statistical analysis and field based empirical work	
Weaknesses / Challenges	• Really struggled with the quality of data	• To maintain a level of intensity for six years in a row. • We are doing so many things compared to a regular research team. • It's still a challenge getting data from companies.	

Table M11-3: Strengths and Weaknesses – Interviews

Question Category	Interviewee D (Industry – owner co-chair)	Interviewee E (Industry – member)	Interviewee F (Industry – member)	Interviewee G (Industry – member)
Strengths	• The academics are very strong. • The graduate students do a lot of the work. • A core group – a common goal and expectations.	• I think the strength of the team is the people we have on it. • The internal teamwork.	• There's been a core group involved from day one. • The experienced people. They really have a best interest in the results and the findings of the team.	• We have real construction guys who manage work and who tend to have stronger personality. • We listen and we are willing to provide input.
Weaknesses / Challenges		• Time constraints on the academics and their students trying to do field studies. • Really tough to get data from other CII companies.	• Team size – a lot of members. • Due to economy, started losing participation. • Struggled to get enough projects.	• Nine people dropped out.

Table M11-3, continued.

Besides the above strengths, Interviewee A mentioned about a cycle approach, access to company data and tool validation as strengths as well. A cycle approach referred by Interviewee A means repeating a one year research process every year throughout the whole period as quoted below. This interviewee pointed out its advantage was having flexibility in team turnover.

> *"Cycle approach. …… Those phases gave good gate points if individuals want to step off that can be not too disruptive or if people join the team. We purposely designed that way realizing that in a six year project there will be turnover so for us it is a really key to design that kind of process-repeat more or less year to year. Also helped lend some predictability to what is necessary to stay involved."*

Interviewee B also commented about the advantages of a long-term project. First, Interviewee B said that *"because it's a six year program"*, the team got through *"the learning curve and then became very productive"*. He also said that the team was *"not constrained by the lifecycle of a typical research team"* which enabled the team to collect *"empirical"* and *"statistically valid data"* that would take *"a longer period of time"*.

Weaknesses commented by the interviewees included data amount and quality issues, team size and team attrition and participation issue due to economic downturn. The data quality issue was noted by Interviewee A. He said that the team *"really struggled with the quality of data" that the team "got from different companies"*. He mentioned that there were *"all sources of accuracies of data"* since data collected from different companies in many cases were based on different codes or bases. He added that there were *"so much variability and noise"* in data that the team collected.

When asked about any unique aspect of the team, Interviewee A answered the timeframe of the research project and the scope which he said *"pretty broad"*. Interviewee C mentioned about the team's effort to present their work outside the team or CII Annual Conference. He said that some of the team members made presentation overseas, such as in South America or in the Middle East.

> *"We did a big effort in terms of presenting our work in many different venues and tried to motivate people to participate in our activities. I think we had that opportunity because it is a four or five year project. Usually, a team goes to CII Performance Improvement Workshops after they finish the research, right? And, we went to PIW to present our results and to get people's interests and participation and again BOA, events that are nothing to do with CII, like the Construction Users Roundtable (CURT) presentations, even in other countries. I did presentations what we were doing in Brazil, Carl did it in Canada and London, and we had some participant, who did it in the Middle East. We try to spread what we are doing and encourage people to participate."*

2.3 RESEARCH METHODOLOGY

2.3.1 Scoping

Key comments from the interviewees in regard to research scoping are listed Table M11-4.

According to the interviewees, it took the team 6 to 8 months to scope out the research and to get the alignment on the scope. The interviewee commonly mentioned that the team did not have any alignment issues during the initial scoping phase, but there was an alignment issue with CII in regard to the research direction. Once the team had the research direction approved by CII, the research scope and direction stayed same throughout the process.

One interesting point is that this scope changed was initiated by the industry members. The industry members did not agree with the research direction laid out in the proposal that the academics had submitted to and that was approved and selected by CII. Interviewee F said that the team *"disagreed with the objectives basically"*. He mentioned that the academics' proposal that had been approved by CII *"didn't make all complete sense"* to the industry members on the team. He added that the team needed to change the research direction. Interviewee G recollected that the industry members *"convinced the academics"* that the team needed to change the direction. This interviewee further commented that the industry members were able to persuade the academics since the academics *"were willing to listen"* and the industry members were *"not afraid of talk out"*. When this interviewee was asked if the research methodology or data collection methods changed due to the scope change, the interviewee answered *"not really"*. He clarified that *"it turned out to be a better definition"*, *"broader"* and *"more stabilized"*.

Interviewee B made a notable comment in regard to the bond built between the academics and industry members. He pointed out that the academics supported industry member initiative (the research direction change), which led the industry members support to *"some of ideas academics had"*.

> *"…because of that academics supported that industry initiative within the team, because it wasn't really a part of our proposal, but because of that academics supported it, that, I think, created a bond of trust between academics and industry members and a sort of mutual understanding. I think that also would let industry members to being supportive of some of ideas academics had at the very beginning and tolerating academic studies. What I am saying is that we could give something to them and also keep the other parts, like CII Benchmarking & Metrics analysis."*

Question Category	Interviewee A (Academic – PI)	Interviewee B (Academic – PI)	Interviewee C (Academic – PI)
Scoping Phase	• First nine or ten months.	• Six months.	• A couple of face-to-face meetings to reach an alignment.
Alignment around the Scope	• From phase I to phase II, there was still an alignment issue - not within our team	• Tremendous alignment of the team around [a tool].	
Scope Change	• No, certainly at this point, it's a more less set. It's got more stability. In the initial phase, it was quite fluid.	• The original plan in the proposal changed over time.	• We didn't change the overall plan we had in mind in the beginning.

Table M11-4: Scoping – Interviews

Question Category	Interviewee D (Industry – owner co-chair)	Interviewee E (Industry – member)	Interviewee F (Industry – member)	Interviewee G (Industry – member)
Scoping Phase	• Six or eight months		• First six or eight months	
Alignment around the Scope	• Had to do some discussions with CII, but the team was pretty aligned from day one.		• Six-month effort	
Scope Change		• [We were] very strong in our opinions how we should go about changing the direction.	• No issues once we were aligned to that central objective.	• [The team] title change – we did as a group.
Industry Member Background Study	• [The members provided] personal experiences	• We have had assignments along the way. Doing some web research, doing a few articles, somebody's research papers, etc.	• I don't think that any of the team members spent a lot of time in research.	

Table M11-4, continued.

Interviewee B also mentioned about the importance of listening to the industry members when he was making comments about scope change.

> *"The original plan in the proposal changed over time because of the findings in the files and because academics listened to our industry members. We discovered something much more useful. Very important to listen to industry members. We understand research methodology and science, principles of science, but industry has a great, great insight into what the real problems are and some tools are useful."*

When asked about if the industry members did any background studies such as literature review or presentations of their company cases relevant to the topic, the industry interviewees provided mixed responses. Interviewees D and F mentioned that the industry members provided their experience rather than doing particular studies while Interviewee E said that the industry members had *"assignments"* such as *"web research"* or *"a few articles"*.

2.3.2 Data collection

Key comments from the interviewees in regard to the data collection process are listed Table M11-5. According to the research reports produced by this team, the data collection methods used were case studies including interviews, field observations, surveys and use of CII Benchmarking & Metrics data. The responses of the interviewees in regard to their data collection methods appeared consistent with those described in their research reports. Interviewee C described their data collection process as *"a multi-step kind of process that involved several kinds of data collection efforts"*. The industry interviewees attributed the data collection to work of the PIs and their graduate students. Interviewee E said that *"the academics drove that research and data collection very well"*.

Interviewee E commented that *"the most difficult part"* during the data collection process was *"getting projects"* and *"willing to submit the data"* to the team. He thought that was *"probably the weak link in the whole research"*. Interviewee A mentioned that the team had *"data accuracy issues"* which eventually the academics went out to collect data again.

> *"……we realized that we got a lot of noise in that data. Data didn't make much sense. We realized that we would need to go out and get performance factor data. Again, back to that accuracy issues we see a lot in companies. It's related to our research, but it is outside of the scope of research."*

Question Category	Interviewee A (Academic – PI)	Interviewee B (Academic – PI)	Interviewee C (Academic – PI)
Data Collection	• Direct observations. • CII BM&M data collection • Survey	• Site visits for getting data	• Collected data from BM&M • Surveys, interviews, case studies • Site visits
Data Collection - Challenges	• Data quality • A challenge to make sure we get enough industry data to statistically validate it.		• The first thing is to find projects that are willing to receive us.
Data Collection - Industry Roles	• They provide intuitive backgrounds that data make sense, why it makes sense, why it doesn't make sense. • They never directly collected data. They provided context of projects.	• Critical feedback on the analytical results	• The main role was to provide contacts. • They give their feedback, they think it makes sense or not.

Table M11-5: Data Collection and Analysis – Interviews

Question Category	Interviewee D (Industry – owner co-chair)	Interviewee E (Industry – member)	Interviewee F (Industry – member)	Interviewee G (Industry – member)
Data Collection		• I think it's been effective. • There's just not enough data points to be statistically relevant.	• I think it was real robust. • They (academics) did gather all the data directly.	• Doing surveys • Actually going out and monitoring the jobs.
Data Collection - Challenges		• Getting projects • The data we've gotten is from the companies of the members of our team.	• There were a few outside, but not by large. • We only had a limited amount of data, projects.	
Data Collection - Industry Roles	• The most of data collection was from academics.	• We review and analyze all the data as a team.	• We did surveys, and we sent them out to our sites.	

Table M11-5, continued.

The role of the industry members during this phase was mainly reviewing what the academics presented during the meetings and providing input and expertise on the analysis done by the academics. The three academic interviewees commonly responded that the industry members provided *"contacts"* for data collection and *"critical feedback on the analytical results"* rather than directly collecting data. The academic interviewees particularly noted that the industry members provided *"intuitive backgrounds that data make sense, why it makes sense, and why it doesn't make sense"* looking at the data analysis presented by the academics in the meetings.

This *"critical feedback"* from the industry members was also commented by the industry interviewees. Interviewee E said that the team did *"review and analyze all the data as a team or suggest"* what the team thought that meant. Interviewee F also said that the industry members *"would look at the information* [presented by the academics] *from the practical perspective"* and provided whether it did or did not make sense and why it did or did not. Besides this, Interviewee D mentioned that when the academics sent surveys to their *"respected companies"* he *"probably did a good enough job getting those surveys filled"*.

Although for the most part the academics collected data, as Interviewee A said *"They* [industry members] *never directly collected data"*, some of the industry members were more involved in the process than other industry members. Interviewee G said that he trained them how to do one of field data collection techniques which his company implemented to improve productivity in fields. This field data collection method was described in one of the two implementation resources that this team has delivered.

The major challenge during the data collection process commonly mentioned by the interviewees was obtaining enough data. In addition to that, according to the industry interviewees E and F, it was a challenge to collect data outside the team member companies. Interviewee E commented that it was very difficult to *"convince"* other companies to provide data as quoted below.

> *"Then the other part has been that really the data we've gotten is from the companies of the members of our team. Trying to convince other companies that don't have anything to do with our team, and maybe they are CII companies, but they don't have a member on our team, trying to convince them to give us data has been very difficult."*

Interviewee F recollected that *"there were a few* [data coming from] *outside* [the team], *but not by large"* and most data were *"team member projects"*. He thought that this was *"the difficult part, the weakness of the team"* adding that the team *"couldn't get other companies not associated with team to provide the information"*.

2.4 TEAM DYNAMICS

2.4.1 Team participation and commitment

Key comments from the interviewees in regard to team diversity and participation are listed Table M11-6.

Overall, the interviewees regarded the team has a good mix of industry members. Interviewee B said that they had *"good age diversity"*, but *"a pretty limited number of women"* and *"a few minorities"*. He commented that *"certainly more diversity would be desirable"*. However, he then added that the team composition has not *"handicapped"* the team so far, and he thought *"the results wouldn't change much"*. In terms of the diversity in expertise or technical background of the industry members, this interviewee characterized it as *"excellent"* and *"a wide variety"* saying that they had *"had people who come up through the trades"* and *"people who are more business oriented"*. According to him, one of co-chairs of this team *"came up to the skill trades"* with *"a manufacturing background"*.

The industry interviewees commonly viewed the team had a *"good mix"*. Interviewee A commented that the industry members had more than 15 years of experience and they were *"pretty knowledgeable people"*. This interviewee said that they were *"more construction oriented than operation company or owner type membership"*. One notable point that this interviewee made was that the team make-up and their experience together with the relationships made the team *"very strong"* in their decision to change the research direction.

> *"I think the fact of the team make-up and the experience that the team had and how comfortable we were with each other, made us very strong in our opinions how we should go about changing the direction. …..…We were willing to stand up and talked to the CII Research Committee. I think that was the direct reflection of the industry members we had and they were comfortable with each other and the thought process we had along with the academics' support that, you know, we were heading the right direction. The other way is going to be very difficult and not fruitful."*

Interviewee F commented about the commonality that the team members had in their experience. He said that the team members *"had all similar roles"* involved in *"implementation of projects"* and the research topic area of this team even though the members were from different types of industries such as nuclear industry or petrochemical industry. The interviewee added that, therefore, the personalities of the members were *"very strong"* and they had *"'get it done' attitude"* which he thought helped the team.

Question Category	Interviewee A (Academic – PI)	Interviewee B (Academic – PI)	Interviewee C (Academic – PI)
Team Diversity		• Good age diversity • Certainly more diversity would be desirable, but I don't think it has handicapped so far.	
Team Attrition		• It has been about 20% turnover every year, roughly.	
Meeting Attendance			• 60%
Core Group	• 6 ~ 7		• 8
Participation & Commitment	• Commitment has really supported research.	• Excellent all the way through. I am very pleased with them.	
Factors for Participation & Commitment	• Status report. I think that's pretty important to make continuity and to maintain team participation.	• We keep them involved. • When you spend time with a member on one or two of his projects, it is a really great way to bond.	• Motivated if they see the importance and value of what they are doing. • Motivation and engagement is a key factor.

Table M11-6: Team Participation and Commitment – Interviews

Question Category	Interviewee D (Industry – owner co-chair)	Interviewee E (Industry – member)	Interviewee F (Industry – member)	Interviewee G (Industry – member)
Team Diversity			• A very good mix. • The industry members all have 15 plus years of experience. • Knowledgeable people.	• Some good personalities.
Team Attrition	• A pretty good mix, but I don't think we have anybody real young on the team.	• Got the full perspective what's happening in the industry.	• Diverse in backgrounds • Personalities are very strong.	
Meeting Attendance		• Over the course of time, we've added a few people.	• Started with 25 or 30. • Members added, other members gone.	• Nine dropped out. • We got four or five more people.

Table M11-6, continued.

Question Category	Interviewee D (Industry – owner co-chair)	Interviewee E (Industry – member)	Interviewee F (Industry – member)	Interviewee G (Industry – member)
Core Group		• About seven industry people that were very strong throughout that whole time frame. • A good core for most of the time that have been involved probably 90% of the meetings and presentations, etc.	• It went down to the core group, probably ten or twelve of us that really did most of the work.	• About eight to ten
Participation & Commitment		• Some pretty strong research team members that dedicated a lot of time.	• That mindset of getting things done and getting things fixed focused helped the team.	• The core group has a high level of commitment and engagement.
Factors to Participation & Commitment	• It should be something they have passion about. • Probably the company they work for has to support that commitment to the research.	• I don't think we've done any special. I think we've just, that core group of the team members saw the value in what we were doing and wanted to stay busy.		• Commitment is to see thing to the end and produce a good product. Because number one is you can develop a pride in what you've done.

Table M11-6, continued.

2.4.1.1 Core group

This team started with 22 industry members plus an academic group of 3 PIs and 2 graduate students according to the team roster as of the kickoff meeting. The most recent research summary listed 15 industry members, 3 academics and 4 graduate students. The first research summary published at the end of its second year of the research process listed 15 industry members, and the second research summary and the third research summary published consecutively every year thereafter listed 14 and 15 industry members, respectively.

In terms of team attrition, the team was able to add new members as the project went on since the research project spanned more than two years. Interviewee B recollected that the team *"probably lose about 20% a year"*, but the team could *"replace"* the loss. He added that the team had *"about 20% turnover every year"*. Interviewee G recalled that the team had 9 members dropped out the team. After CII sending out request for staffing to the member companies, he said that 4 or 5 new members joined. Interviewee E recollected that some of the new members *"came to one or two meetings and faded away"* while 2 or 3 others were *"very active"*. According to the available minutes of the s7even face to face meetings during the first 2 years of the research, the average meeting attendees were about 11 members excluding the academic group.

Of these 15 industry members shown in the 4 research summaries, 8 members were listed on all of the 4 research summaries. This is consistent with the perception of the interviewees in regard to core people of this team. The interviewees said that the team had 8 to 10 core people. Interviewee A described these core people as *"consistently involved"*. Interviewee E said that the core people were *"involved probably 90% of the meetings and presentations"*. Interviewee F commented that 25% to 30% of the team who were core *"actually did most of the work, actually participated in every meeting and other things"*.

When asked about the participation and commitment of the team, the interviewees responded positively. Interviewee E said that the team *"had some pretty strong research team members that dedicated a lot of time"*, and Interviewee G mentioned about *"a high level of commitment and engagement"* of the core group. Interviewee B also said that it was *"excellent all the way through"*. Interviewee A commented that the commitment of the industry members *"really supported research"*. However, he further mentioned that the commitment to writing the research products did not improve.

> *"Commitment has really supported research. We get more support from members when it gets down to the Annual Conference presentation. But the commitment to with the implementation resource and the research summary hasn't necessarily got better. It wasn't great from the beginning.*

But they do seem really become a lot more involved and provide a lot more input when we get in to the Annual Conference cycle. …..…"

2.4.1.2 Factors for team participation and commitment

In regard to the factors that affected the participation and the commitment of the team, the industry interviewees mentioned about engagement, value, passion, support from companies, interest, relationship, and pride. Interviewee D said that the research should be *"something they have passion about" and their companies "has to support that commitment to the research"*. Interviewee E mentioned that the core team members *"saw the value in what"* the team was doing.

As a useful practice to keep up the team with the research process, Interviewee A recommended having monthly webinar as a status report. The interviewee noted that monthly webinars helped the team maintain member continuity and participation although monthly webinars *"never substitutes face-to-face meetings"*.

> *"We have made sure that we have monthly team webinar to provide update.……That sessions really provide information where we are at. Always make sure that lasts no longer than one hour. If you make longer that, it is intrusive to companies.* [It is a kind of] *status report. I think that's pretty important to make continuity and to maintain team participation."*

Interviewee B, one of the PIs, particularly mentioned about recognition of the industry members projects as part of data collection effort. The interviewee commented that visiting the project sites of the industry members made them appreciated and continuously involved with the research.

> *"We keep them involved, but we don't make it too much work and we don't make it boring for them. We keep it interesting. Also, I think we have visited projects of almost every team member, and we have gone to almost every team member's hometown, and that keeps them involved. When you spend time with a member on one or two of his projects, it is a really great way to bond. We have been to all the different projects, it worked well – we were very aggressive at getting out to projects. People appreciate it when you get come to the projects."*

Interviewee C considered "*motivation and engagement*" as key factors for industry member participation and commitment. He further elaborated that "*value and importance*" perceived by industry members on a team is necessary to promote motivation and engagement of a team. As one of approaches to achieve that, the interviewee mentioned that the academics should be good listeners.

> *"It's not about what you think is important. It's about what the team think is important. You have to listen. There are people who listen and are good at coordinate and keep the team moving forward, and there are people in the research community who are not good listeners. They want to do their own thing. And to work in teams, you have to be very good at listening and quickly come up with the plan that you are going to accomplish that goal, something that the team sees importance and value because they are the experts in that topic."*

Interviewee E commented that the economy affected the participation of the team members because their companies would not support further. Other than that, he thought that the team had no issues with participation. He also pointed out that the team built good relationship which also had a positively influence on participation.

Interviewee G viewed commitment as *"to see things to the end and produce a good product"* so that people *could "develop a pride"* in their work. This interviewee provided his experience in regard to how this research helped his career and recognition as quoted below.

> *"Commitment is to see thing to the end and produce a good product. Because number one is you can develop a pride in what you've done. I think it's been good for me in respect because I've actually improved, I wrote a technical article for* [his company] *technology journal, which I wouldn't have done, but I did that. And also, I was asked to speak at the Project Controls conference this year to talk about productivity. I don't if that would've happened, maybe I don't know. I've been also interviewed by ENR* [Engineering News-Record]. *So I was published in ENR, and that visibility carries over my relationship with clients because clients see ENR, and my name is there, and his working on productivity, and he is a* [his company's] *productivity guy, can we get him on our job? So, it actually enhances what I do for the company within my own company because the last job I just got on, the client wanted me to come because the client saw the ENR article last year."*

2.4.1.3 Subgroup approach

In terms of a subgroup approach, the interviewees commonly recollected that the team did not use a subgroup approach. Interviewee A said that the team did work *"as a group as a whole"* adding that from his perspective, working as a whole group seemed *"to be easier to maintain continuity as a group"*. This interviewee further commented that since the team had *"six or seven core people"*, the team did not *"like dividing them* [the core people] *up into smaller groups"*. However, Interviewee E recollected that the

team broke up when they prepared for the Annual Conference presentations. Other than this, the team did not use a subgroup approach.

2.4.2 Leadership

Key comments from the interviewees in regard to team leadership are listed Table M11-7.

2.4.2.1 Industry chairs and PIs

The interviewees described the orientation of leadership as "*good mix*" and "*combination of everybody*" not dominated by academics or industry members. An interesting notion made by Interviewee B was that the academics lead the team behind as much as possible, especially when industry chairs do not have prior CII research experience.

> *"Let's say it's a short term research team, you always, in theory, try to get industry chairs to lead. But, some are stronger and more active, and some are less strong and less active. Really academics are normally leading, but you want to lead behind as much as possible. You don't want the industry chairs to abrogate their responsibilities. You want them to take on much responsibilities and leadership as possibly you can. And yet they may have never done it before, and I have been on seven or eight research teams, and I really know what we should be doing, so we want to make sure."*

The interviewees in general perceived that the team had the strong co-chairs and academics. The team "*lost one chair* [owner co-chair]" due to job relocation, and "*another person*" took the chair position. The team had to change one of the owner co-chairs again later the process, but "*one of the core people*" stepped in the position without a problem. However, the contractor co-chair did not change, according to Interviewee A, which resulted in "*good continuity in chairs*". Interviewee E recollected that even though the team had "*a couple of different co-chairs along the way*", but all the co-chairs "*have been very strong*" and "*very active in their input and the direction*".

Question Category	Interviewee A (Academic – PI)	Interviewee B (Academic – PI)	Interviewee C (Academic – PI)
Leadership Orientation		• I would say you get various types of leadership from five people [two co-chairs and three academics]. • You have to, really academics is normally leading, but you want to lead behind as much as possible.	
Co-chairs	• Industry leadership, in terms of our chairs and industry members, has been good. • Good continuity in chairs. Last year one of chairs stepped down. One of core people stepped in the chair's position.	• Very responsible team leaders.	
PI & co-PI		• I have worked with [the other academics] so long that I do certain things he values and he does certain things I value and it works very nicely.	• We have been working together, so we kind of know each other very well.

Table M11-7: Team Leadership – Interviews

Question Category	Interviewee A (Academic – PI)	Interviewee B (Academic – PI)	Interviewee C (Academic – PI)
Leadership Communication			• We also have some communication for just academics and co-chairs, like leadership aspect of the team for the coordination issues.
Leadership Roles & Responsibilities	• Chairs moderated the meetings • Running the meetings, making decisions and executing strategies are primarily done by academics.	• [Interviewee A] has become the operational leader of the team. • [The co-chairs] are very good at taking their responsibilities seriously.	

Table M11-7, continued.

Question Category	Interviewee D (Industry – owner co-chair)	Interviewee E (Industry – member)	Interviewee F (Industry – member)	Interviewee G (Industry – member)
Leadership Orientation		• A really pretty good mix. It's all been a group effort.	• I would it say it was not led by one particular side or the other. It was an equal partnership and leadership.	
Co-chairs		• Very strong co-chairs. • The co-chairs we've had have been very strong. • Softer kind of leadership. Keeping herding us on the right direction.	• We had excellent chairs. Very active, set the expectation. • The two chairs, the leadership style, I think it was by example.	• They stayed core. • I think the main thing that chairs did was just to make sure everybody stay focused and did what they were supposed to do.
PIs	• You got good differences in personalities. • Deep in research experience. • All three of them have touched industry and done industry work.	• Having three academics has been very good. • It's been very beneficial we have three different academics because that three different perspectives and ideas to go forward.	• Just excellent to work with. Very proactive. • Very passionate about what they do. • Always did a good job with being prepared for the meetings. • They were very open to listen to it and understand it.	• The academics listened. I think that really helped the entire group.

Table M11-7, continued.

Question Category	Interviewee D (Industry – owner co-chair)	Interviewee E (Industry – member)	Interviewee F (Industry – member)	Interviewee G (Industry – member)
PI & co-PI		• Each one's got their strength. • It's pretty much been a team-led effort, not an individual-led effort in most cases other than the person trying to keep us on track, and that's probably [Interviewee A].	• They did a great job of understanding that role and pushing that down to a level that we can give them what they need quickly enough.	
Leadership Roles & Responsibilities	• I don't see differences. [Interviewee A] is kind of a focal point of our team. He kind of herds the cats. He leads the meetings. • They [academics] are the ones who knew the timeline and the scale looking forward as we put together schedule.	• The academics have been pretty the lead in keeping the calendar for us, and keeping that on track. • [Interviewee A] has been like the leader of the process of meeting organization.	• I think we shared tasks. • Typically the academics prepared most of the agendas, prepared most of the presentations, and typically took the notes.	

Table M11-7, continued.

The styles of the co-chairs, according to Interviewee E, were *"leadership by example"*. He added that the co-chairs kept the team *"on the right direction"*. Interviewee D also made a similar comment that the co-chairs *"kept the team focus"* and *"very dedicated"*. Interviewee E mentioned about the dedication and commitment of the contractor co-chair. The contractor co-chair moved his job location outside the United States, but he *"still made his way back for almost every face-to-face meeting and all the conferences* [where the team reported out every year]". Interviewee further commented that it was *"a big commitment for him* [the contractor co-chair] *and even his company."* This contractor co-chair participated on two prior CII research teams, one of which he served as a co-chair. Therefore, as Interviewee E noted, this co-chair was *"familiar with the process"* as well.

In terms of the academics, the industry interviewees perceived that the academics were *"outstanding"* and *"excellent to work with"*. Interviewee D noted that all three PIs had industry experience, so the academics were able to *"relate some of their experiences"* to the experiences of the industry members. The interviewee also commented about the advantage of having three academics as presented below.

> *"Having three academics has been very good. Three academics know each other very well, bouncing ideas off each other very well, and it has been totally supportive about the team."*

Interviewee F described the academics as *"very proactive about the* [research] *results"* and *"very passionate about what they do"*. In addition, the academics *"did a good job with having an agenda and research"* and were *"very open to listen to"* the industry members.

> *"Very open to listen to, again, we* [industry members] *maybe did not agree with what they were saying. They were very open to listen to it and understand it, and then did go back and rethink this and try this way, that way."*

Interviewee F also noted that the academics listened to the industry members, which the interviewee thought very helpful for the team.

> *"As far as the academics, the academics listened. I think that really helped the entire group was they were willing to try to understand and listen."*

2.4.2.2 Leadership roles and responsibilities

The roles and responsibilities were clearly separate between the academics and industry leaders as well as between the three academics. The meetings were led by the

academics, and the chairs *"moderated the meetings"* when discussions went *"too long"*. The interviewees generally indicated that Interviewee A was *"a leader of the team"* and *"focal point"* from the team operational perspective. The academics split the work between them based on the expertise of each academic since they were in different institutions and they had their own graduate students.

Interviewee B described Interviewee A as *"the operational leader of the team"*. According to this interviewee, the co-chairs focused on *"interfacing with CII"* and *"making important decisions"* in regard to allocation of team resources where necessary.

> "[Interviewee A] *has become the operational leader of the team. He will make sure that we are on time and we are covering all of the actions from the last meeting, he will schedule the conference calls and usually manage conference calls, so he has really become, I would say, the leader of the team……My* [Interviewee B's] *role would be more long-term vision keeping us focused on our objectives and maybe generating ideas.* [Interviewee C's] *great strength, I think, he does everything really, but his one great strength is analytical rigor when it comes to research he is extremely rigorous."*

> *"Two industry members* [the co-chairs] *are very good at taking their responsibilities seriously in terms of interfacing with CII, making important decisions about commitment of team resources on certain conferences to assigning people to certain activities. They are very good about that. But they won't run the meeting, not minute by minute."*

Interviewee E also said that the academics split the work among the three and *"each one has their own strength"* which were similar to the comments of Interviewee B above.

> *"They sort of split the range among the three of them. Each one's got their strength. When we've looked at the analysis of previous data,* [Interviewee A] *has taken the lead on going back and using his graduate student to analyze the CII BM&M database……*[Interviewee C] *has taken the lead on the research and data analysis of data we had to support the* [the tool that the team developed]*……*[Interviewee B] *has sort of been to gather and bring new ideas and thoughts."*

Interviewee D, the owner co-chair, noted that the academics kept the schedule *"because they know what is due"*. He further elaborated that the academics were *"the ones who knew the timeline and the scale looking forward"* as the team put together schedule and *"the academics have been pretty the lead in keeping the calendar"* for the team. According to Interviewee F, the academics typically *"prepared most of the agendas"* and *"most of the presentations"*, and the graduate students took the meeting notes.

2.4.3 Team communications

Key comments from the interviewees in regard to team communication are listed Table M11-8.

2.4.3.1 Team relationship and conflicts

The industry member interviewees recollected that the team did not have conflicts within the team. Interviewee E described that *"the entire process has been very congenial"*. Interviewee F said that the conflicts between owner members and contractor members *"never came up"*.

> *"It never came up. Again, I think it goes back to the type of people and the quality of how we defined what we wanted for the end product kept us all focused. Not so much what I was a contractor or an owner, but we had a common purpose of achieving something that we both will benefit by……We understood it is win-win for everybody if we participate correctly and participate together. You win, I win, and then we all go home. I think that helped a great deal. Not a lot of conflict. No issues, no conflicts."*

Then, Interviewee F further elaborated that the team *"listened openly and honestly to different opinions, different experiences, and accepted those experiences"*. However, he added that there were *"some differences in opinion"* since there was one team member from the manufacturing industry with *"a different mindset"*.

This was also pointed out by Interviewees A and B. Interviewee A commented that *"one person wanted to take the whole to a whole different direction"*, and Interviewee B recalled that the team had one industry member *"who had a very unique perspective"* and was *"aggressive at pursuing it"*. According to Interviewee B, that member from the manufacturing industry did not want to continue the team because *"the team was not moving in his direction"*.

Question Category	Interviewee A (Academic – PI)	Interviewee B (Academic – PI)	Interviewee C (Academic – PI)
Team Relationship and Conflicts	• No open conflicts. • One person wanted to take the whole to a whole different direction.	• We had one fellow particularly who had a very unique perspective and he was aggressive at pursuing it.	• We have a very cohesive group.
Team Meetings		• Not to let a strong or loud small group dominate. I think that's really important.	• We meet every two months.
Team Communications	• Monthly team webinar to provide update.		• Face-to-face meetings, webinars, emails, conference calls.
Social Activities	• Team dinners.		

Table M11-8: Team Communications – Interviews

Question Category	Interviewee D (Industry – owner co-chair)	Interviewee E (Industry – member)	Interviewee F (Industry – member)	Interviewee G (Industry – member)
Team Relationship and Conflicts	• No [conflicts]. Not that I know of.	• The entire process in my opinion has been very congenial.	• We've got to know each other better than probably a 2-year research team will. • It [conflict] never came up. Not really.	
Team Meetings		• We meet face-to-face probably four to six times a year on average, and we usually have a teleconference on the month not meeting face-to-face.	• Quarterly face-to-face meeting. • Every other week: teleconference.	• We usually have one online meeting once a month and we have a quarterly face to face, and then once a month online, a conference call.
Team Communications	• Emails, webinars, conference calls, face-to- face meetings.	• Other than our face-to-face meetings, email was how we communicate between meetings. • Web meetings.		• Face-to-face meetings, online meetings, conferences calls, and emails.

Table M11-8, continued.

Question Category	Interviewee D (Industry – owner co-chair)	Interviewee E (Industry – member)	Interviewee F (Industry – member)	Interviewee G (Industry – member)
Social Activities	• Team dinners.		• We tried to make a point do something outside the team.	• We did some good team building things. We have always had team dinners.
GRA		• We have had great and really bright graduate students working with us over the years.		

Table M11-8, continued.

2.4.3.2 Team meetings and communications

The team met every two or three months in person and had conferences calls in between with monthly webinars. Interviewee G said that the team *"had very interactive meetings"* with an agenda established in prior and following the agenda every meeting. Interviewee E noted that the team *"has the opportunity to jell, get to know each other, and build that relationship, especially over the time"* of six years through face-to-face meetings.

Interviewee B commented about the meeting facilitation. He particularly mentioned about the importance of encouraging less vocal members to speak out their opinions.

> *"It is very important because some of them have very good insight but they are just shy or they are not pushy personalities. You can get a really, really great insight out of them. And, people who were ignoring conversation feel like they can't ignore anymore because they keep getting asked. So they begin to engage. It's like a classroom, right? Also they feel recognized and valued being asked by names. Not to let a strong or loud small group dominate. I think that's really, really important."*

2.5 PRODUCT DESIGN AND DEVELOPMENT

Key comments from the interviewees in regard to research products are presented Table M11-9.

2.5.1 Key considerations

Interviewee E and Interviewee G noted that key considerations in developing their research products included providing *"an overall guide or encyclopedia of work practices"* that *"somebody can use for information"* as well as that *"somebody can understand"* and *"utilize it"*. Interviewee E compared their implementation guides as *"the overall roadmap"* and *"reference tool"* indicating *"here are all the tools out there."* Interviewee G pointed out that producing *"a product that makes sense"* to users is an important consideration.

2.5.2 Product development and industry involvement

The team produced 12 products which are 4 research summaries, 5 implementation resources, and 3 research reports over the research period. Since its research period was longer than a typical CII research period and the team was required to report out at the CII Annual Conference every year starting the second research year, the team produced the products accordingly.

Question Category	Interviewee A (Academic – PI)	Interviewee B (Academic – PI)	Interviewee C (Academic – PI)
Industry Member Involvement	• My only complaint about the team is the research summary, in theory industry writes the research summary and academics write the research report, never works that way. We [the academics] write it. • Written part of reports, they [the industry members] do more reviewing and editing.		
Product Quality	• Both [implementation] guides statistical analysis show that both of them are valid.	• I would say it has been the best of all the teams I have been on.	• I think [the products are] pretty good.
Feedback	• We have published two [journal papers]. Feedback I think is generally positive.	• Several people just spontaneously told us that [the products] were useful documents.	• The feedback from the people who used it has been pretty positive.

Table M11-9: Research Products – Interviews

Question Category	Interviewee D (Industry – owner co-chair)	Interviewee E (Industry – member)	Interviewee F (Industry – member)	Interviewee G (Industry – member)
Key Considerations		• We are looking at just an overall guide or encyclopedia of work practices.		• Well, obviously number one is you want to produce a product that makes sense that somebody can understand it.
Industry Member Involvement	• Implementation resources: editors and co-authors.	• As far as the research summary, I'd say it's probably 75% academic and 25% industry with us having review side of it. • The [implementation] guides had been more industry-led with a lot of data processing and input to put together. 50: 50 or 60:40, industry side.	• Some of us wrote the executive summary, and some of us wrote subchapters.	• The academics prepare the first draft. • Usually what we do is to edit and provide input to or make assignments.
Product Quality	• They [the products] are very good.	• The [implementation] guides, I think, are very good.	• I think the products are very usable and high quality.	• Pretty good.

Table M11-9, continued.

When asked about the industry members' participation in producing actual research documents, the research summaries and the implementation resources, Interviewee A mentioned about the discrepancy between the reality and the ideal as presented below.

> *"My only complaint about the team is the research summary, in theory industry writes the research summary and academics write the research report, never works that way. We* [the academics] *write it. We try to get that* [the industry members write the research summary]. *But it doesn't come back well enough to meet CII expectations. ……* [Nevertheless,] *always make sure at least one industry member write the executive summary and conclusions to put that in the industry voice. That has been my recurring challenge to make industry members write the research summary and the implementation resources but comes back to academics. You have to do that and understand that. It is a reality."*

The industry interviewees noted that the academics prepared the drafts of the research documents. However, they pointed out that the industry members were involved with producing the contents, reviewing and providing input. Interviewee E commented that the industry members were heavily involved with developing the implementation guide and the one of the tools they produced was *"industry driven"*.

> "[The implementation resources] *have had heavy involvement from the industry team members..…… a lot of the work and the bulk of the work really came from the industry. The editing and supporting in documentation, pulling the whole thing together was the academics, but the industry guys really said this is what you do and this is how you do it. And really came out with that guide, specifically two of our team member were very involved in the authorship of that implementation document.. .....As far as the research summaries, I'd say it's probably 75% academic and 25% industry with us having review side of it. The guides had been more industry-led with a lot of data processing and input to put together still coming from the academics because they have time with the research and grad assistants, etc. to pull all that together. 50: 50 or 60:40, industry side."*

2.5.3 Product quality and feedback on the products

The interviewees were very satisfied with their research products. They perceived that their products as statistically valid, usable and useful with high quality. When asked any feedback on the research products from other CII member companies or from the academia, the industry interviewees recalled that they had not received any feedback yet. The three academic interviewees said that they received feedback from both the industry and the academia, and they recalled that feedback was positive.

Bibliography

Abowitz, D. A. & Toole, T. M. (2010). Mixed method research: fundamental issues of design, validity, and reliability in construction research. *Journal of Construction Engineering and Management*, 136(1), 108-116.

Amabile, T. M., Patterson, C., Mueller, J., Wojcik, T., Odomirok, P. W., Marsh, M., & Kramer, S. J. (2001). Academic-practitioner collaboration in management research: A case of cross-profession collaboration. *Academy of Management Journal*, 44(2), 418-431.

Amaratunga, D., Baldry, D., Sarshar, M., & Newton, R. (2002). Quantitative and qualitative research in the built environment: application of "mixed" research approach. *Work study*, 51(1), 17-31.

Anderson, E. S., Birchall, D., Jessen, S. A., & Money, A. H. (2006). Exploring project success. *Baltic Journal of Management*, 1(2), 127-147.

Andras, P. (2011). Research: metrics, quality, and management implications. *Research Evaluation*, 20(2), 90-106.

Azhar, S. (2007). Improving collaboration between researchers and practitioners in construction research projects using action research technique. *Proceedings of 43rd ASC National Annual Conference (CD-ROM)*. Associated Schools of Construction (ASC), Flagstaff, Ariz. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.96.8172&rep=rep1&type=pdf

Azhar, S., Ahmad, I., & Sein, M. K. (2010). Action research as a proactive research method for construction engineering and management. *Journal of Construction Engineering and Management,* 136(1), 87-98.

Bammer, G. (2008). Enhancing research collaborations: three key management challenges. *Research Policy*, 37(5), 875-887.

Barnes, T., Pashby, I., & Gibbons, A. (2002). Effective University–Industry Interaction: A Multi-case Evaluation of Collaborative R&D Projects. *European Management Journal*, 20(3), 272-285.

Barnes, T. A., Pashby, I. R., & Gibbons, A. M. (2006). Managing collaborative R&D projects development of a practical management tool. *International Journal of Project Management*, 24(5), 395-404.

Batunek, J. M. (2007). Academic-practitioner collaboration need not require joint or relevant research: toward a relational scholarship of integration. *Academy of Management Journal*, 50(6), 1323-1333.

Boaz, A., Fitzpatrick, S., & Shaw, B. (2009). Assessing the impact of research on policy: a literature review. *Science and public policy*, 36(4), 255-270.

Brown, J. H. (2004). Facilitating research utilisation. *The International Journal of Public Sector Management*, 17(6), 534-552.

Buckley, M. R., Ferris, G. R., Bernardin, H. J., & Harvey, M. G. (1998). The disconnect between the science and practice of management. *Business Horizons*, 41(2), 31-38.

Butcher, J., & Jeffrey, P. (2007). A view from the coal face: UK research student perceptions of successful and unsuccessful collaborative projects. *Research policy*, 36(8), 1239-1250.

Charlton B. G., & Andras, P. (2007). Evaluating universities using simple scientometric research-output metrics: total citation counts per university for a retrospective seven-year rolling sample. *Science and Public Policy*, 34(8), 555-563.

Colman, A. M., Dhillon, D., & Coulthard., B. (1995). A bibliometric evaluation of the research performance of British university politics departments: publications in leading journals. *Scientometrics*, 32(1), 49-66.

Committee on Science, Engineering, and Public Policy (U.S.) (1999). *Evaluating federal research programs: research and the Government Performance and Results Act*, National Academies Press, 1999. Retrieved from http://www.nap.edu/catalog/6416.html

Construction Industry Institute (1993), *CII: The First Ten Years, SP37*. The University of Texas at Austin, Austin, TX

Construction Industry Institute (2013), *CII 2012 Annual Report, AR-2012*. The University of Texas at Austin, Austin, TX

Construction Industry Institute Benchmarking and Metrics Committee (2011). *CII Value of Best Practice Report*, CII Benchmarking and Metrics Program. Unpublished report.

Construction Industry Institute (2008). *Building On 25 Years, CII-25*. The University of Texas at Austin, Austin, TX

Construction Industry Institute (2012). *CII Publication Guide (8th ed.)*, Retrieved from https://www.construction-institute.org/research/Downloads/2012PubGuide.pdf

Construction Industry Institute (2010). *Quality CII Research – Criteria and Characteristics*. Retrieved from https://www.construction-institute.org/research/res-quality.cfm?section=res

Construction Industry Institute (2013). *Request for Qualifications*, Retrieved from https://www.construction-institute.org/research/res-RFQ.cfm?section=res

Construction Industry Institute website, https://www.construction-institute.org

Davenport, S., Davies, J., & Grimes, C. (1998). Collaborative research programmes: building trust from difference. *Technovation*, 19(1), 31-40.

de Wit, A. (1988). Measurement of project success. *Project Management*, 3(1), 164-170.

De Vaus, D. (2001). *Research design in social research*. Sage, 225-226.

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., & Trow, M. (1994). *The new production of knowledge: The dynamics of science and research in contemporary societies.* Sage, 1994.

Green, S. D., Kao, C. C., & Larsen, G. D. (2009). Contextualist research: iterating between methods while following an empirically grounded approach. *Journal of Construction Engineering and Management*, 136(1), 117-126.

Halpin, D. W. (2007). Fifty years of progress in construction engineering research. *Journal of Construction Engineering and Management*, 133(9), 635-639.

Hodgkinson, G. P., & Rousseau, D. M. (2009). Bridging the rigour–relevance gap in management research: it's already happening!. *Journal of Management Studies*, 46(3), 534-546.

Hughes, T., Bence, D., Grisoni, L., O'regan, N., & Wornham, D. (2011). Scholarship That Matters: Academic–Practitioner Engagement in Business and Management. *Academy of Management Learning & Education*, 10(1), 40-57.

Katz, J. S., & Martin, B. R. (1997). What is research collaboration?. *Research policy*, 26(1), 1-18.

Kim, S. & Gibson, G. E. (2002). *Assessment of CII knowledge implementation at the organizational level, RR166-11*, A report to Construction Industry Institute, the University of Texas at Austin, Austin, TX.

Kishchuk, N. (2005). Performance report: SSHRC's major collaborative research initiatives (MCRI) program. *Ottawa, Ontario: SSHRC.*

Kosstoff, R. N. (1996). Performance measures for government-sponsored research: overview and background. *Scientometircs*, 6(3), 281-292.

Kulatunga, U., Amaratunga, D., & Haigh, R. (2007). Performance measurement in the construction research and development. *International Journal of Productivity and Performance Management*, 56(8), 673-688.

Kulatunga, U., Amaratunga, D., & Haigh, R. (2011). Structured approach to measure performance in construction research and development: Performance measurement system development. *International Journal of Productivity and Performance Management*, 60(3), 289-310.

Lim, C. S. & Mohamed, M. Z. (1999). Criteria of project success: an exploratory re-examination. *International Journal of Project Management*, 17(4), 243-248.

Littler, D., Leverick, F., & Bruce, M. (1995). Factors affecting the process of collaborative product development: a study of UK manufacturers of information and communications technology products. *Journal of Product Innovation Management*, 12(1), 16-32.

Love, P. E., Holt, G. D., & Li, H. (2002). Triangulation in construction management research*. *Engineering Construction and Architectural Management*, 9(4), 294-303.

Lucko, G. & Rojas, E. M. (2010). Research validation: challenges and opportunities in the construction domain. *Journal of Construction Engineering and Management*, 136(1), 127-135.

Maxwell, J. A. (2005). Qualitative research design: An interactive approach, 2nd edition, pp69-70. Thousand Oaks, CA: SAGE Publications.

Miles, M. B. & Huberman, A. M. (1994). Qualitative Data Analysis, pp18-22. Thousand Oaks, CA: SAGE Publications.

Mohrman, S. A., Gibson, C. B., & Mohrman, Jr., A. M. (2001). Doing research that is useful to practice: a model and empirical exploration. *Academy of Management Journal*, 44(2), 357-375.

Moncaster, A., Hinds, D., Cruickshank, H., Guthrie, P. M., Crishna, N., Baker, K., Beckmann, K., & Jowitt, P. W. (2010). Knowledge exchange between academia and industry. *Proceedings of the ICE-Engineering Sustainability*, 163(3), 167-174.

Mora-Valentin, E. M., Montoro-Sanchez, A., & Guerras-Martin, L. A. (2004). Determining factors in the success of R&D cooperative agreements between firms and research organizations. *Research Policy*, 33(1), 17-40.

Patton, M. Q. (2001). Qualitative research and evaluation methods. pp. 230-346. Thousand Oaks, CA: SAGE Publications

Phelps, A. & Horman, M. J. (2010). Ethnographic theory-building research in construction. *Journal of Construction Engineering and Management*, 136(1), 58-65.

Pertuze, J. A., Calder, E. S., Greitzer, E. M., & Lucas, W. A. (2010). Best practices for industry-university collaboration. *MIT Sloan Management Review*, 51(4), 83-90.

Pinto, J. K., & Covin, J. G. (1989). Critical factors in project implementation: a comparison of construction and R&D projects. *Technovation*, 9(1), 49-62.

Rynes, S. L., Bartunek, J. M., & Daft, R. L. (2001). Across the great divide: Knowledge creation and transfer between practitioners and academics. *Academy of Management Journal*, 44(2), 340-355.

Ruegg, R., & Feller, I. (2003). *A Toolkit for Evaluating Public R & D Investment: Models, Methods, and Findings from ATP's First Decade.* US Department of Commerce, Technology Administration, National Institute of Standards and Technology.

Sexton, M., & Lu, S. L. (2009). The challenges of creating actionable knowledge: an action research perspective. *Construction Management and Economics*, 27(7), 683-694.

Schubert, Petra, & Julie Fisher (2009). A Blueprint for Joint Research between Academia and Industry. *Proceedings of the 22nd International Bled eConference*, 14-17.

Sicotte, H., & Langley, A. (2000). Integration mechanisms and R&D project performance. *Journal of Engineering and technology management*, 17(1), 1-37.

Sillars, D. N., & Hallowell, M. R. (2009, April). Opinion-based research: lessons learned from four approaches. *In ASCE Construction Research Congress Conf. Proc.*, Seattle.

Starkey, K., & Madan, P. (2001). Bridging the relevance gap: aligning stakeholders in the future of management research. *British Journal of Management*, 12(s1), S3-S26.

Stokols, D., Misra, S., Moser, R. P., Hall, K. L., & Taylor, B. K. (2008). The ecology of team science: understanding contextual influences on transdisciplinary collaboration. *American journal of preventive medicine*, 35(2), S96-S115.

Suomala, P. & Jokioinen, I. (2003). The patterns of success in product development: a case study. *European Journal of Innovation Management*, 6(4), 213-227.

Tushman, M. L., O'Reilly, C., Fenollosa, A., Kleinbaum, A. M., & McGrath, D. (2007). Relevance and rigor: Executive education as a lever in shaping practice and research. *Academy of Management Learning & Education*, 6(3), 345-362.

Van de Ven, A. H., & Johnson, P. E. (2006). Knowledge for theory and practice. *Academy of management review*, 31(4), 802-821.

Werr, A., & Greiner, L. (2008). Collaboration and the production of management knowledge in research, consulting, and management practice. *Handbook of collaborative management research*, 93-117.

Wong, J., & Gray, J. M. (2010). A discussion of the research performance evaluation in building and construction management discipline: the journal impact factors and SCI-index journals. *Proceedings of the 26th Annual of the Association of Researchers in Construction Management (ARCOM)*, 1, 757-766.

Yin, R. K. (2009). Case study research: Design and methods, 4th edition. Thousand Oaks, CA: SAGE Publications.

Vita

Junghye Son was born in Busan, the Republic of Korea. She entered Yonsei University in Seoul, Korea in 1991. She received the degree of Bachelor of Science in Architectural Engineering from Yonsei University in February, 1996. In August, 1997, she entered Texas A&M University in College Station, Texas. She received the degree of Master of Science in Civil Engineering with a specialization in Construction Engineering and Management in December, 1999. Upon graduation, she returned to Korea and joined Hyundai Engineering and Construction Company as a project engineer in the Department of Construction Project Management in January, 2000. In January 2002, she joined the Airport Railroad Company, a special purpose company executing planning to operation and management of a railroad project linking the center of Seoul City and the Incheon International Airport located in Younjong Island. While she served as an assistant manager and a manger for the construction phase of the project, she was responsible for managing foreign and domestic project management contracts, developed and implemented the Project Management Implementation Plan, and developed company project management procedures among others. In August 2008, she entered the Graduate School at the University of Texas at Austin to pursue her doctorate in Civil Engineering specializing in Construction Engineering and Project Management. Since 2008, she has been working with the Research Committee, the Academic Committee, and the Breakthrough Strategy Committee at the Construction Industry and Institute (CII).

Email address: junghye.son@utexas.edu, sonjunghye@gmail.com

This dissertation was typed by the author.